



This is a digital copy of a book that was preserved for generations on library shelves before it was carefully scanned by Google as part of a project to make the world's books discoverable online.

It has survived long enough for the copyright to expire and the book to enter the public domain. A public domain book is one that was never subject to copyright or whose legal copyright term has expired. Whether a book is in the public domain may vary country to country. Public domain books are our gateways to the past, representing a wealth of history, culture and knowledge that's often difficult to discover.

Marks, notations and other marginalia present in the original volume will appear in this file - a reminder of this book's long journey from the publisher to a library and finally to you.

Usage guidelines

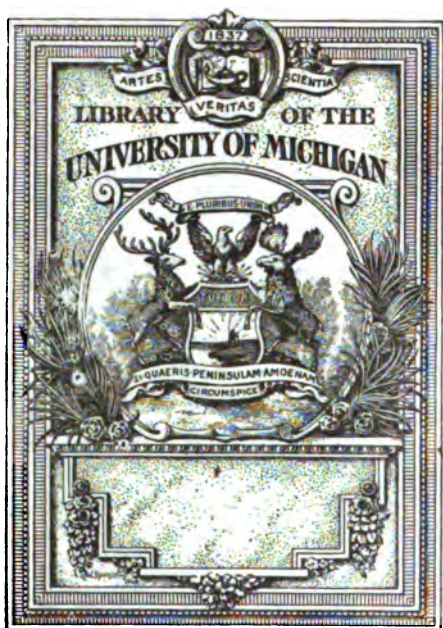
Google is proud to partner with libraries to digitize public domain materials and make them widely accessible. Public domain books belong to the public and we are merely their custodians. Nevertheless, this work is expensive, so in order to keep providing this resource, we have taken steps to prevent abuse by commercial parties, including placing technical restrictions on automated querying.

We also ask that you:

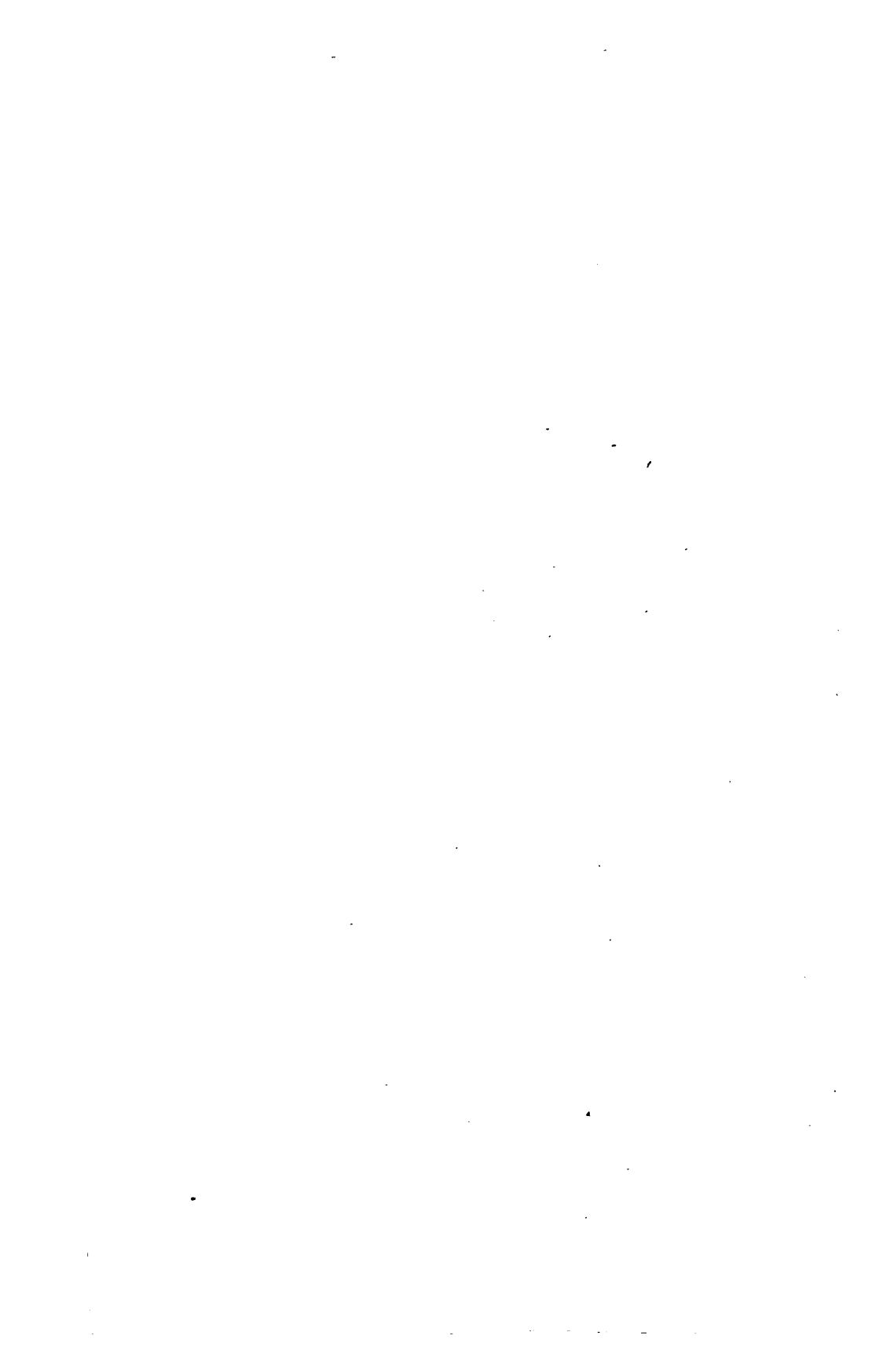
- + *Make non-commercial use of the files* We designed Google Book Search for use by individuals, and we request that you use these files for personal, non-commercial purposes.
- + *Refrain from automated querying* Do not send automated queries of any sort to Google's system: If you are conducting research on machine translation, optical character recognition or other areas where access to a large amount of text is helpful, please contact us. We encourage the use of public domain materials for these purposes and may be able to help.
- + *Maintain attribution* The Google "watermark" you see on each file is essential for informing people about this project and helping them find additional materials through Google Book Search. Please do not remove it.
- + *Keep it legal* Whatever your use, remember that you are responsible for ensuring that what you are doing is legal. Do not assume that just because we believe a book is in the public domain for users in the United States, that the work is also in the public domain for users in other countries. Whether a book is still in copyright varies from country to country, and we can't offer guidance on whether any specific use of any specific book is allowed. Please do not assume that a book's appearance in Google Book Search means it can be used in any manner anywhere in the world. Copyright infringement liability can be quite severe.

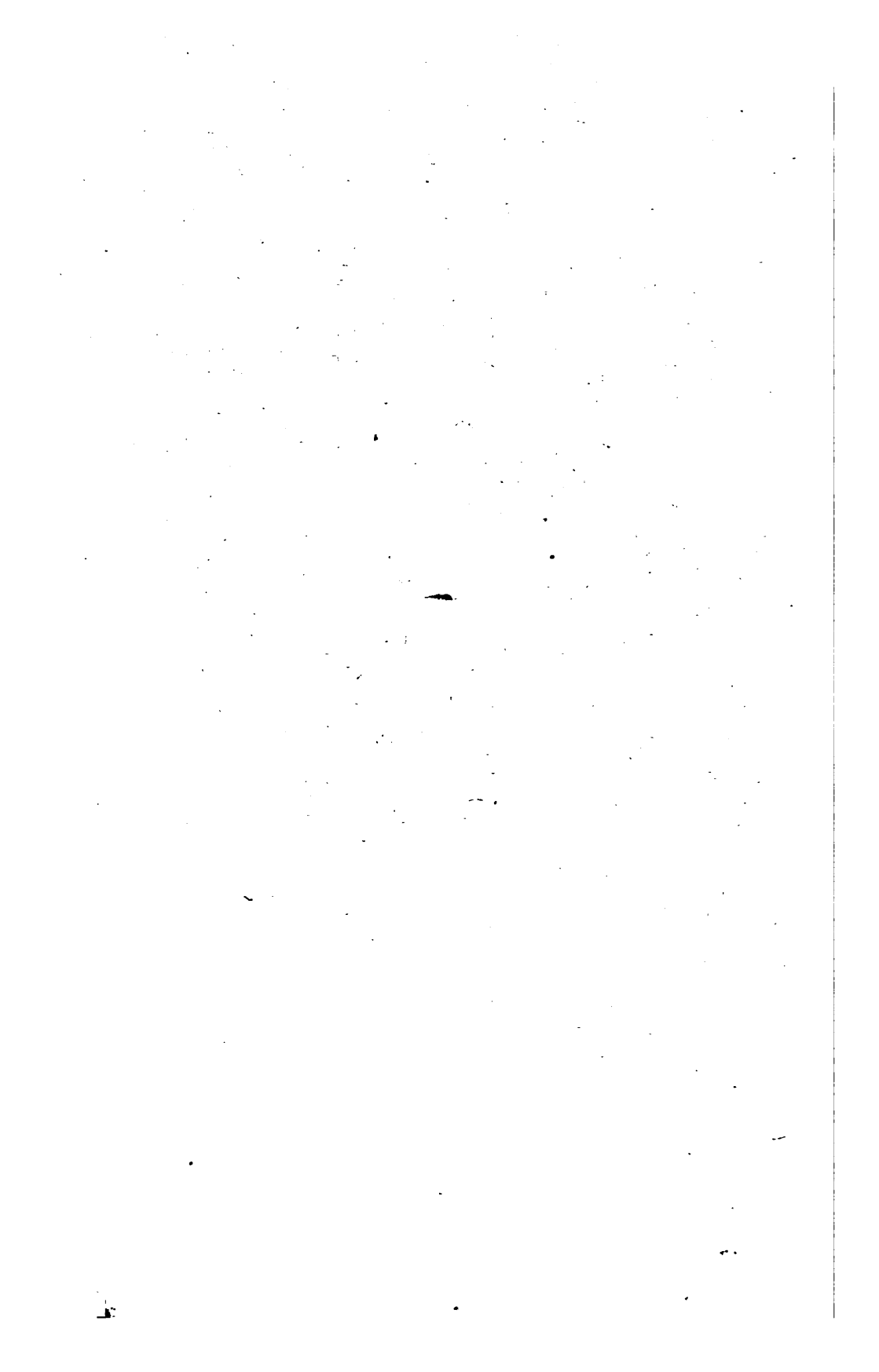
About Google Book Search

Google's mission is to organize the world's information and to make it universally accessible and useful. Google Book Search helps readers discover the world's books while helping authors and publishers reach new audiences. You can search through the full text of this book on the web at <http://books.google.com/>



3
9<
E9





Bulletin 62.

January 1894

Cornell University Agricultural Experiment Station.

HORTICULTURAL DIVISION.

Received from Agricultural Experiment Station

THE
Japanese Plums
IN NORTH AMERICA.



By L. H. BAILEY.

PUBLISHED BY THE UNIVERSITY.

ITHACA, N. Y.

1894.

ORGANIZATION.

BOARD OF CONTROL: THE TRUSTEES OF THE UNIVERSITY.

STATION COUNCIL.

President, JACOB GOULD SCHURMAN.

HON. A. D. WHITE,	-	-	-	-	Trustee of the University.
HON. JOHN B. DUTCHER,	-	-	-	-	President State Agricultural Society.
I. P. ROBERTS,	-	-	-	-	Professor of Agriculture.
G. C. CALDWELL,	-	-	-	-	Professor of Chemistry.
JAMES LAW,	-	-	-	-	Professor of Veterinary Science.
A. N. PRENTISS,	-	-	-	-	Professor of Botany.
J. H. COMSTOCK,	-	-	-	-	Professor of Entomology.
L. H. BAILEY,	-	-	-	-	Professor of Horticulture.
H. H. WING,	-	-	-	-	Asst. Professor of Dairy Husbandry.
G. F. ATKINSON,	-	-	-	-	Asst. Professor of Cryptogamic Botany.

OFFICERS OF THE STATION.

I. P. ROBERTS,	-	-	-	-	Director.
HENRY H. WING,	-	-	-	-	Deputy Director and Secretary.
E. L. WILLIAMS,	-	-	-	-	Treasurer.

ASSISTANTS.

M. V. SLINGERLAND,	-	-	-	-	Entomology.
GEO. C. WATSON,	-	-	-	-	Agriculture.
G. W. CAVANAUGH,	-	-	-	-	Chemistry.
E. G. LODEMAN,	-	-	-	-	Horticulture.

Offices of the Director and Deputy Director, 20 Morrill Hall.

Those desiring this Bulletin sent to friends will please send us the names of the parties.

BULLETINS OF 1894.

62. The Japanese Plums in North America.

THE JAPANESE PLUMS IN NORTH AMERICA.

In 1870, Mr. Hough, of Vacaville, California, secured several plum trees from Japan through Mr. Bridges, a United States Consul in that country, at a cost of ten dollars each. These trees soon passed into the hands of the late John Kelsey, of Berkeley, California, who obtained the first ripe fruit in 1876 or 1877. Mr. Kelsey became convinced of the value of the plum for general cultivation, and its propagation upon an extensive scale was begun in 1883 by W. P. Hammon & Co., of Oakland, who afterwards named it in memory of Mr. Kelsey, and who made large sales in the planting season of 1884. Subsequently, other parties, particularly Luther Burbank, of Santa Rosa, California, made importations of plum trees from Japan, and have disseminated the varieties widely. For the past four or five years, these plums have awakened more interest throughout the country than any other new or recent type of fruits ; and it has been found, contrary to the early opinion, that many of them are adapted to the northern States. While they are often inferior in quality to the best garden or Domestica* plums, they possess various desirable characteristics which the others do not, particularly great vigor and productiveness of tree, comparative freedom from disease, great beauty, and long-keeping qualities ; and the best of them compare well in quality with the common plums.

* The term Domestica plums is used to distinguish the common cultivated plums, all of which have sprung from the European *Prunus domestica*, from the Native and Japanese types.

The term Japanese plum is used only for these varieties of *Prunus triflora* now under consideration, and does not include the Bungo or Bongoume types, which are apricots and which will be treated in a future bulletin. The Apricot or Simon plum (*Prunus Simonii*) has been already discussed in Bulletin 51. The so-called Japan plum of the extreme south is the loquat, and is foreign to the purpose of this bulletin.

The native plums and cherries are treated in detail in Bulletin 38.



Original specimens of Prunus triflora in the Kew Herbarium.

For many years after the introduction of the Kelsey, there seems to have been little speculation as to the origin or botanical

position of these oriental plums; but as the varieties increased and began to attract general attention, a demand arose for a knowledge of their genesis. A plum found in the botanic gar-



Winter buds of three species of Plums—*Prunus domestica*, *P. triflora*, and *P. hortulana*.

dens at Calcutta about seventy years ago by Roxburgh, and by him named *Prunus triflora*, seemed the most likely parent; but as there were some difficulties in his characterization of the species, and as subsequent botanists have not found the wild form, and as Maximowicz, the most eminent botanist who has recently given careful attention to these oriental floras, does not identify the cultivated plum flora of

Japan with Roxburgh's species, I accepted for a time a name proposed by Professor Kizo Tamari, of Tokio, *Prunus Hattai*, and published it as the best means of classifying our knowledge of these plums until the proper botanical name should be determined. In 1891, Professor Georgeson, of the Kansas Agricultural College, who had spent some years in Japan in a critical study of its pro-

ducts, definitely referred these plums to *Prunus triflora* of Roxburgh, in an article in *American Garden*. It now remained to consult the dried botanical specimens which Roxburgh left of his species. The accompanying illustration shows the specimens in the Kew Herbarium, England, part of which appear to be from Roxburgh himself; and the others are from the Ava Hills of north-western India, probably from cultivated plants, collected by N.C. Royle. Upon these specimens nearly all our knowledge of *Prunus triflora* seems to rest. I am not able to say which of the specimens in the illustration were collected by Roxburgh, but all are essentially alike, and I have no hesitation in saying that our cultivated Japanese plums are the same.* The types in cultivation vary much

*The synonymy of these plums will therefore stand as follows:

PRUNUS TRIFLORA, Roxburgh, Hort. Bengal. 38 (1814).

P. trifolia, Fl. Indica, ii. 501 (1824).

P. Hattan, Tamari Mss; Bailey, Annals Hort. 1889, 30, and Amer. Gard. xii. 74 (1891).

Prunus japonica, of horticulturists.

The following is Roxburgh's description of the species in his Flora of India, p. 501. In this work the plant is called *Prunus trifolia*, probably through inadvertence.

"Unarmed. Peduncles tern. Leaves oblong, very finely gland-serrate, smooth, in the bud equitant. Drupes cordate.

"Chin. Hong-sum-li.

"This elegant very ramous bushy shrub has been received from China, into our gardens in Bengal, where it blossoms in February, immediately after which the luxurious foliage expands, and the fruit, which is about the size of the common plum, and nearly as palatable, ripens in May and June.

"Trunk in our young cultivated trees, or rather shrubs, very short, soon dividing into numerous branches and branchlets in all directions from diverging to erect. Bark on all smooth. Leaves alternate, in the bud equitant, petioled, recurved, oblong, tapering equally at each end, very finely gland-serrate, considerably acuminate, smooth, from two to four inches long, and from one to two broad, in Bengal deciduous about the close of the year. Stipules from the base of the petioles, ensiform, gland-ciliate. Flowers very numerous, rather small and white, short peduncled, regularly three from each bud, and there are generally two of those buds in each of the old axills, with a leaf-bearing one in the center. Bractes, the scales of the bud, cordate, scarious, and nearly caducous. Calyx, segments five, oblong; margins glandular. Petals oval, short-clawed, the length of the peduncles. Filaments about thirty, shorter than the petals. Germ ovate, one celled, containing two ovula attached to the same side of the cell. Style the length

COMMON PLUMS (*Prunus domestica*).—Trees of moderate and more or less crooked growth, with not roughened gray or purplish and often pubescent young wood and single pointed buds and large, protruding leaf-scars; flowers usually one to two from a bud, large and opening wide, mostly long-stalked; leaves mostly large, thick and heavy in texture and prominently netted and often pubescent below, dull above, varying from ovate to round-ovate to broadly obovate in outline, blunt or the point not pronounced, conspicuously obtusely toothed or sometimes almost jagged; fruit globular or oblong or even oboval but not prominently pointed, with a large, flat, pointed and winged pit.

JAPANESE PLUMS (*Prunus triflora*).—Trees of strong growth with widely spreading long forked branches which are light colored and marked with corky elevations, the young growth not pubescent, the buds three or more at the joint, and the leaf-scars often small; flowers mostly two to three from each bud, generally rather small and short-stalked and sometimes not opening wide; leaves firm but rather thin in feeling and not pubescent nor rough-netted below although the whitish veins are pronounced, very smooth and often somewhat shiny above, commonly long-ovate or sometimes nearly elliptic in outline and the point usually prominent, the edges marked with fine close serratures; fruit globular or more often conical and with a deep depression at base and a very prominent suture, the flesh clinging to or free from the smooth or lightly pitted scarcely winged pit.

But these Japanese plums are more nearly allied botanically to our native plums, particularly to the Wild Goose type, than they are to the Domestica class. This may be seen even in the twigs on page 5, of which No. 4 is the Wild Goose. And this similarity to our native species is really, to my mind, one of the strongest points in their favor, for it indicates that they will be likely to adapt themselves to a very wide range of our great country, inasmuch as we may fairly assume that similarity of attributes has been produced by similarity of environment. This conviction of their kinship with our native species and the knowledge that they come from the eastern Asian region from which we draw so many of our adaptive plants, has led me to recommend them strongly for trial even in our more trying fruit regions;

ly one or two from each bud. The buds are often aggregated upon short spurs in the Japanese varieties as seen in the drawing



Ogon.



Kelsey.

upon page 4, and the flowers are then crowded into showy masses, as in the picture of Ogon herewith. Upon the longer shoots where the buds are but three at a joint, the clusters are less evident, as in the accompanying illustration of Kelsey, yet their glomerate character is always more marked than in the Domestica. Brief characters of separation may be drawn between *Prunus domestica* and *P. triflora* as follows :

plum, have been introduced in Japan, but are not generally known, and those regions reached by the Kaikakushi in its attempts to introduce and naturalize foreign fruits. The Kaikakushi was the name of a department of the government (commonly translated Colonization Department), which, however, was abolished long ago. Its object was to colonize the northern island with Japanese, and to this end large numbers of fruits and other economic plants from the West were introduced, the climate there being somewhat like that of central and northern Europe." If the Domestica plums are little known in Japan, it may also be said that the Japanese plums appear to be wholly unknown in Europe,* unless possibly in Russia; and it is therefore not probable that any serious confusion of varieties has occurred between the two species. It is very important, then, that a complete record of this species should be made while yet it is confined to comparatively isolated areas of the globe.

Botanical position of the Japanese plums.—There is a striking difference in the winter characters of trees of Japanese and Domestica plums. The Japanese varieties tend to make long and forking branches, with a light colored, rough, somewhat peach-like bark which is marked by numerous corky elevations, while the Domesticas are closer and more bushy growers, with a dull gray or purplish, tight, smooth bark. But the greatest differences lie in the buds. The engraving (page 5) shows at No. 1 a twig of the Coe's Golden Drop, a Domestica plum; this, in common with all varieties of the species, has single and pointed buds. The Japanese varieties usually have their buds in threes, as in the twig of Burbank (No. 2), or sometimes even in fours or fives, as in the shoot of Kerr (No. 3), and these buds are small and blunt. Three flowers commonly spring from each flower-bud of the Japanese varieties and it was this circumstance which led Roxburgh to call the species *Prunus triflora* or three-flowered plum; while in the Domestica type the flowers are more common-

* Naudin, for instance, in his admirable *Manuel de l'Acclimatateur* (1887) knows the species (which he calls, erroneously, *Prunus japonica*) only from an account of the recent introductions into California contained in the *Gardener's Chronicle*.

amongst themselves, but I have been unable to make more than one species out of them; and the variation is considerably less than in the families or groups of the *Domestica* plums, which botanists are pretty well agreed have descended from a single specific type.

This plum is probably native to China. Roxburgh said that the species was introduced in Calcutta from China, and upon this assertion Hemslay admits it to his recent Flora of China, having "only seen specimens cultivated in the Calcutta Botanic Garden." There is no record, so far as I know, of its occurrence in a native state in Japan. Professor Georsson remarks that its cultivation is old in Japan and that its origin is uncertain; and an exploration of the forests of Japan, was unable to find wild plants. Much of the interior and western portion of China is unexplored botanically, and it is not strange that the aboriginal type of this interesting fruit is yet undiscovered. According to Bretschneider* the plum was anciently cultivated in China, which indicates an indigenous origin.

Maximowicz, Hemslay and other botanists seem to be confused with the resemblance of *Prunus triflora* to *P. domestica*, and it has also been said by various pomologists that some of the plums recently imported from Japan are only varieties of the *Domestica* type. While botanical specimens of the two may strongly resemble one another, the species are nevertheless readily distinguished, even in winter; and I have not yet seen a plum of Japanese origin which can be referred to *Prunus domestica*. In fact, the *Domestica* plums seem to be little known in Japan. Professor Georsson, writing upon this point, makes the following statements:† "The varieties of this species, which is our common

of the stamina. Stigma large. Drupe cordate, with an obtuse rising at the apex, the size of the common plum, and of the same purple colour, covered with a similar bloom, grooved on one side. Pulp in large quantity, of a pale reddish yellow. Seed single, conform to the nut. Integument single. Perisperm a thin covering on one side only. Embryo inverse. Cotyledons unequal, the small one doubled, and embraced by the larger, subequitant." * Bretschneider, On the Study and Value of Chinese Botanical Works, 10,

45.

† Amer. Gard. xii. 75.

and recent reports indicate that some varieties bear so far north as Ottawa, Ontario, and in the trying winters of central Iowa; and one, at least, of Professor Budd's Russian plums is of this species. Several pomologists have been struck with this similarity of the Japanese and native types; and, strangely enough, Dr. A. B. Dennis of Cedar Rapids, Iowa, in endeavoring to explain this relationship in a recent paper before his State Horticultural Society, by supposing a former land connection between northwestern America and Asia, has independently hit upon one of the important points in the coincident evolution of the Japanese and eastern American floras, the discussion of which, over thirty years ago, made Asa Gray famous.

It may be well, in passing, to consider for a moment the possible effect of this new class of plums upon the further development of our native species. I am sorry to hear from some of my friends who have given careful attention to the amelioration of the natives, that they shall now relax their efforts upon the native types and accept the Japanese sorts in their stead. It is true that the Japanese plums are now better in fruit, for all that we can see, than the natives, but we can depend upon it that they will develop weak points somewhere, even in comparison with the little improved natives; and we should further consider that all types of plums now in the country, or likely to come in, add variety and diversity to the foundation upon which our horticulture must build, and make it possible to develop fruits for every variety of country and use. And if the Japanese plum promises more for large areas of our country than the European or *Domestica* type because of its evolution in conditions somewhat like our own, certainly the native species must possess still greater promise. The native species are yet scarcely rescued from the woods, while the other two have been cultivated for centuries; but while the latter have sprung from a single species in their respective countries, our native stock offers at least a half dozen species, and it is from them, without a doubt, that the greater part of the American plum industry will some day be found to have sprung.

Nomenclature and classification of varieties.—There is much confusion in the nomenclature of the Japanese plums. If the varieties imported from Japan have been named at all, they have

usually come as Botan or Botankio, Hattankio or Sumomo (generally written Smomo); but these names refer to classes or groups of varieties, and the attempt in this country to apply them definitely has resulted in confusion. It may also be said that the Satsuma or Blood class appears to comprise several varieties. The Sumomo class is characterized by small globular fruit, with a firm sweet flesh, ripening very early. The Botans or Botankios are larger and later round plums, while the Hattans or Hattankios are conical. The terms are applied loosely even in Japan, and it does not seem to be worth while to endeavor to retain them here, particularly as there appear to be all manner of gradations between the types of the different groups. There has been some misconception of the application of these terms and it is often said that they refer to color rather than to shape. Upon this point, Professor Georgeson explains as follows :*

“Quite a number of the many other varieties [than the Sumomos] springing from this species are designated by two general names, a fact which is very confusing to a stranger when he begins to study them. These names are botankio and hattankio, or bodankio and hadankio, for they are variously pronounced as regards the sound of *d* and *t*. These two names are common and are even occasionally heard in this country; but it is a mistake to suppose that they apply to two and only two varieties. They are names of two ill-defined classes of plums, and are applied rather loosely to several varieties which differ in color and size and somewhat also in shape. The only distinction between the two classes that I have been able to establish is based on the shape. The round plums are designated by the term botankio, while those of an oval or pointed shape are called hattankio. A mistake often made by foreigners, and by some natives also, is to suppose that the distinction is based on color, though it is a fact that most of the botankios are red. The name hattankio is also sometimes given to the almond, while botan is the name of the pæony, and ha-botan means cabbage, and one of the many meanings of kio, or kiyo, is large, or great. If these objects had anything to do with the naming of the plums it seems probable that botan referred to the rounded shape and not to the color, since their peonies

* Amer. Gard. xii. 74.

The Hattankio type of Plum. From a Japanese drawing. (See page 14.)



are found in a great variety of colors, and that hattankio referred to the resemblance in shape to the almond. But as already remarked, these names are used very loosely, as it is an easy matter to find several evidently quite distinct varieties of each class for which both grower and dealer can give you no other name than botankio or hattankio, as the case may be. Sometimes again these terms may have a prefix indicative of the color, or size, or of the place where it is grown."

There are various colors in each of these classes of plums, from deep purple to light red, yellow and nearly white. The Hattankio class seems to be the commonest in this country, being represented by the Kelsey, Burbank, Satsuma, Abundance, Berckmans, Normand, Kerr. The accompanying illustration of the Shiro (or White) Hattankio, made in Japan under Professor Georgeson's supervision, represents the typical characters of the class, and affords at the same time an admirable botanical characterization of *Prunus triflora*. The Botans are represented here chiefly by Ogon and Willard; while the Sumomos seem to be known only in the little cherry-like Berger, shown natural size upon the cover, and which passes under a variety of names. The Japanese plums might be divided into two general groups upon the color of the flesh—the yellow-fleshed and the red-fleshed or Satsumas, but this classification would serve little purpose, although the Satsumas seem to be recognized as a class by my Japanese correspondents.

Professor Tamari, of Tokio, makes a somewhat different application of these terms, although he is less specific in explanation of them. If I understand him correctly,* he uses Smomo as a generic term for plum. There are then three classes of plums, as follows:

1. Hatankio. Habit and growth slender, the young branches straight and erect, leaves large and long and of light color; fruit not sour but rather bitter when young,† freestone, never colored in skin or flesh, but the skin becomes yellowish green and afterwards slightly tinted with purple-red. Kelsey plum is cited as an example.

* Proc. 16th meeting Ga. Hort. Soc. (1891), 45.

† It should be said that the Japanese use green fruits of plums and apricots for eating.

Botankio is a sub-group of this, characterized by round fruit.

2. Beni-Smomo, or red-fleshed plums. Three names are chiefly used, evidently somewhat loosely, for varieties in this group: Honsmomo, Yonemomo, and Uchi-Beni.

3. Smomo proper, comprising fruits "either colored or not in the skin, but never colored inside."

This classification is of little service so far as the varieties known in America are concerned, and it shows that we may as well discard entirely the loose group-names of the Japanese. The methods of cultivating fruits in Japan enforces the adoption of local and generic names, and there seems to be little attempt to apply specific names with the certainty and distinctness with which they are used here and in Europe. "Plum trees," Professor Georgeson writes, "are rarely found planted in orchard form, as are the pears, for instance, but they are scattered here and there about the dwelling houses or in the gardens, wherever the situation may appear to be suitable. It is also exceptional to find trees that receive much care or training. The bearing branches are often broken off and carried away bodily. It is not uncommon during midsummer to meet a pedestrian with a plum branch loaded with green fruit, on his shoulder. It may be a present from a friend, or it may be intended for sale, but it shows at all events that the owner has no great regard for his tree." In such conditions of cultivation it is not strange that no specific attention is given to names of the different forms.

The earliest attempt made in this country to classify and describe the varieties of Japanese plums, was an excellent essay by L. A. Berckmans in the Proceedings of the Georgia Horticultural Society for 1889. This essay, in modified form and with illustrations, appeared in *American Agriculturist* for January, 1890.

Characteristics of the Japanese plums.—About thirty varieties of Japanese plums are now named and more or less disseminated in this country, and others are known by numbers or indefinite appellations. Nearly all of the named sorts, if, in fact not all varieties, are direct importations from Japan; but unnamed seedlings are now coming to be known to experimenters and the time must be near at hand when a varied American progeny will come

into the market. Judging from Professor Georgeson's account, there is still abundant material upon which to draw in the mother country, however: "The wonder is rather that our enterprising nurserymen and plum-growers have apparently been content with these two or three varieties [many more have now appeared], and that they have not instead gone in search of more and perhaps hardier plums of the same kind; for it might reasonably be supposed that a country which could produce those we have would be likely to have others equally worthy of notice. Such, at any rate, is the fact. There are many varieties in Japan which are fully equal to the so-called Kelsey, Ogon and Botan, which are already known here. Let him who doubts this visit the fruit stands in the Japanese portion of Yokohama during June and July. He will be gratified by the sight of a greater collection of varieties than can be found in any horticultural exhibit in this country. Tokio is also well supplied with plums at this season, and so are other towns throughout the country; but the region about Yokohama and a little southward is especially noted for its plums." These places are near the center of Japan, where the climate is mild; but Japan extends over some fifteen degrees of latitude and it is not strange, therefore, that varieties of various degrees of hardiness should be obtained from the empire. Unfortunately, the Kelsey was the first Japanese plum to become known in this country, and as it is hardy only upon the Pacific coast and south of Virginia, it became a general impression that the species is not adapted to cultivation in the north. The varieties which are now known to be hardy in the plum regions of New York and Connecticut are Burbank, Abundance, Willard, Ogon, Satsuma, Berger, Chabot, and Yosebe; and most others give promise of hardiness. Dr. Dennis reports Burbank and Ogon to have borne at Cedar Rapids, Iowa, last season, after having experienced a temperature 26° below zero. Early blooming will probably prove to be a more serious weakness of these plums than lack of hardiness; and this point is discussed farther on (p. 32).

The season of these plums varies considerably. The earliest to mature in central New York is the little Berger, which ripens the middle of July. The earliest of what may be called the market

varieties, in this latitude, seems to be Willard, which colors sufficiently for market about the 15th of July in ordinary seasons, and which is fully ripe for eating a week later. Ogon follows, coming in about the first of August, or sometimes late in July, or about ten days ahead of Wild Goose. Late in August or very early in September, the Abundance is ready. Just before the Abundance, a soft and handsome plum, which is either Berckman's or very close to it, has interested me upon the grounds of S. D. Willard, at Geneva, N. Y. Bradshaw, alongside the above varieties, ripens late in August, and Field is about a week earlier; and as these two varieties are the earliest well-known market plums of the *Domestica* type in New York, it will be seen that the Willard has a great commercial advantage. Burbank ripens here about the first week in September, or sometimes the second week. In central Louisiana, J. L. Normand gives the following as the common succession of varieties: Georgeson, ripening the first days in June or sometimes the last of May; Kerr, about twelve days later; Berckmans; Abundance; Normand; Burbank; Chabot; Bailey, ripening early in July; Satsuma; Kelsey, two weeks later than the last. Kelsey is evidently the latest of all the Japanese plums yet known in this country. I have received specimens not fully ripe from Central Florida as late as the 20th of July, and it has been known to ripen in Georgia as late as the first of October.

As a class, the Japanese plums are long keepers. Even when they are fully colored and grown and are fit to eat, some varieties will keep nearly two weeks, and most of them will keep a week; and some, if not all of the varieties ripen up well if picked rather green, after the manner of a pear, although they may suffer in quality from such treatment. Willard, picked when beginning to color on the exposed side, I have kept nine days in good condition in a warm room and with no attempt to preserve them; Abundance picked August 24, when well colored, began to decay September 2; Burbank, partly colored and picked August 24th, were placed in a tight box in a warm room, and on September 5th they were nearly all in perfect condition and had colored well, but were not even then fully ripe; a red plum, much like Berckmans, kept from September 18th to October 1. J. H. Hale, of

Connecticut, reports keeping Satsuma two weeks in his office in good condition, and they were fairly ripe when picked.

Varieties.—An attempt will now be made to describe the varieties of Japanese plums which are known in North America. The nomenclature is so much confused and many of the varieties so imperfectly known, that I cannot hope to have arrived at just conclusions in regard to the proper names and descriptions of all of them; but the attempt will serve to classify and fix our knowledge of the varieties and I hope that it will lead others to make a more prolonged study of them. It is particularly difficult to determine which is the proper type of any variety in those cases in which two or three fruits pass under the same name, and I presume that some of the following names may be found to be wrongly applied. On the other hand, it is very probable that some of the varieties which are here kept distinct may prove to be identical. Some of the varieties I know only from printed descriptions, but I have added them for the purpose of making the monograph complete. Many growers have given me great aid in the preparation of this descriptive list, amongst whom I should mention P. J. Berckmans, of Augusta, Georgia, and S. D. Willard, Geneva, N. Y., without whose coöperation I could scarcely have attempted this essay.

It has seemed best to discard entirely the Japanese class-names, as Botan, Botankio, Hattankio, Sumomo and the like, as they only lead to confusion. I have therefore renamed some of the varieties which are passing under indefinite names or numbers. The introduction of the name Abundance for the plum first known as Yellow-Fleshed Botan has been severely criticized in some quarters, but I have always felt that the renaming was not only justifiable but essential to lucid nomenclature. If the other Japanese generic names had been supplanted several years ago, much of the present confusion would have been avoided.

In rating the size of the varieties, Kelsey, of course, must stand 10; and in comparison with this standard even 7 or 8 represents a large plum.

It does not seem to be necessary to adopt any classification of these plums, and I have therefore listed them alphabetically. The most serviceable classification would be one founded upon color of skin and flesh. The varieties might be arranged as follows:

A. Yellow-skinned plums:

Georgeson,	Kerr,
Normand,	Ogon.

B. Red-skinned plums:

1. *Yellow flesh.*

Abundance,	Babcock,
Berckmans,	Bailey,
Burbank,	Berger,
Kelsey,	Chabot,
Long Fruit,	Maru,
Munson,	Orient,
Perfection,	Red Nagate,
Strawberry,	Willard,
	Yosebe.

2. *Red flesh.*

Delaware,	Hale,
Heikes,	Late Blood,
Satsuma,	Uchi-Beni.

1. *Abundance* (Yellow-Fleshed Botan).—Medium in size (or large when thinned) varying from nearly spherical to distinctly sharp-pointed, the point often oblique; ground color rich yellow overlaid on the sunny side with dots and splashes of red, or in some specimens nearly uniformly blush-red on the exposed side; flesh deep yellow, juicy and sweet, of good quality when well ripened, cling. A strong-growing upright tree with rather narrow leaves, and a decided tendency to overbear. This is the best known of all Japanese plums in the north, and its popularity is deserved. Ripe here in early September or late August; in eastern middle Georgia late in June.

Imported by Luther Burbank in 1884. Named Abundance and put upon the general market by J. T. Lovett, in 1888. The illustration (Plate I) shows average Abundance as grown in New York, without thinning, three-fourths natural size. I have seen the fruit nearly twice as large from trees which were thinned. The fruit is apt to rot badly in wet seasons, unless well thinned.

2. *Babcock* (Botankio. Botan, of some).—Medium to large ($1\frac{1}{2}$ – $1\frac{3}{4}$ in. diam.), round, conical, skin yellow overlaid with purplish red, rather thick; flesh, deep orange and solid, a little coarse, sweet, of good flavor and quality, cling; rather late,

ripening about with the Burbank, or about a week earlier than Chabot in the south.

Imported in 1885 by Luther Burbank. Now named for Col. E. F. Babcock, a well-known nurseryman of Little Rock, Arkansas, and among the first to grow and recommend the variety.

3. *Bailey*.—Large, nearly globular, with only a slight tendency to become conical; ground color rich orange, overspread with light and bright cherry-red, and showing many minute orange dots; flesh thick and melting, yellow, of excellent quality, cling. Tree strong and upright, productive. Closely related to Burbank, but rounder and mostly larger, and a week or more later.

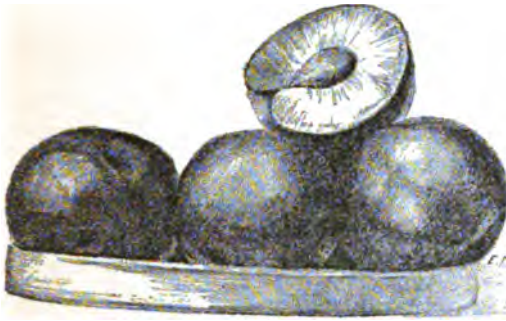
Imported by J. L. Normand, Marksville, Louisiana, and by him named and introduced in 1891. Figured in *American Gardening*, xiii. (1892), p. 700. There appears to be another Bailey plum of the *Domestica* type. I know it only from a plate made by Dewey of Rochester and which declares that it "has not failed to bear for twenty-five successive years." The Rochester Lithographing Co., successors to Dewey, write me that this plate was in Dewey's stock before 1886, but that they know nothing further about it.

4. *Berckmans* (True Sweet Botan. Sweet Botan. White-Fleshed Botan. Botan. of some).—Medium (or slightly above if thinned), broadly and obtusely conical and somewhat angular in cross-section; deep blood red if ripened in the sun; flesh very sweet, moderately juicy, excellent in quality, cling or semi-cling; ripens with Abundance or just ahead of it. One of the best.

Introduced by Luther Burbank in 1887, from imported stock. The variety does not appear to be a true Botan, and its nomenclature is so confused and indefinite that I have renamed it for Mr. Berckmans, who has done much to popularize it. I am not sure if the true variety has been fruited in the north, but forms which are evidently the same bear well in New York. The illustration in Plate II is made from specimens received from Mr. Berckmans.

5. *Berger*.—Fruit very small and globular, bright uniform red, with a firm, meaty and sweet yellow flesh and a very small free stone, ripening as early as the middle of July in some parts of New York and Connecticut.

The picture shown here and upon the title-page is natural size. The fruit is very distinct in appearance and cannot be mistaken for any other Japanese plum which I have seen. Mr. Berckmans sends it to me without a name, saying that it came from H. H. Berger & Co., of San Francisco, as Red Nagate. N. S. Platt



Berger. Full size.

sends it from Connecticut as Satsuma, the name under which it was received from Berger. It comes from the south (also originally from Berger) as Shiro Smomo. I also have it from

Western New York, unnamed. T. V. Munson, Texas, sends specimens which he calls the Berger, and I have adopted his name, although I do not know if he has published it. He writes as follows of it: "The Berger plum is an upright, cherry-like tree. It bears a purple fruit about the size of the Black Tartarian cherry, with meaty flesh, nearly free stone which is as small as the pit of the common Black Morello cherry and much the same shape." Mr. Berckmans says that the "tree is very vigorous and distinct in growth, but a shy bearer. The fruit is too small to be worthy of being retained." What I have seen of this fruit, however, leads me to believe that it may be a useful sort for the home garden because of its earliness, daintiness and pleasing flavor. Professor Georgeson, to whom I have submitted specimens, pronounces it a Sumomo.

Blood: see *Satsuma*.

Botan: see *Abundance*, *Babcock*, *Berckmans*, and *Willard*. There are evidently other plums in the country passing as Botans which are little known and which have not received distinctive names.

Botankio: see *Babcock*.

6. *Burbank*.—Medium, to rather large upon thinned trees, roundish conical in form, the point generally blunt; ground color

orange-yellow, mostly rather thinly overlaid with red and showing many yellow dots, often more or less marbled, in the sun becoming rather dense red; flesh firm and meaty, yellow, rich and sugary, cling. Strongly resembles Abundance both in fruit and tree, but the fruit averages larger and of better quality, rather handsomer in its varied markings, and is from two to four weeks later. Exceedingly productive. One of the best of the Japans.

Imported by Luther Burbank, Santa Rosa, California, late in 1885, and named for him by H. E. Van Deman. See Rept. Dept. Agr. 1891, p. 392, where it is also given a good colored plate. Generally introduced in 1890. The accompanying illustration shows the prevailing form of the Burbank, half-size.

7. *Burbank No. 1*.—Said to resemble Berckmans. I do not know it.



Burbank. Half size.

8. *Burbank No. 2*.—Described as of medium size, regular and globular in shape, yellow overspread with purplish carmine, with a yellow very juicy flesh which is fine-grained and of good quality; pit nearly free. Very early. This variety is not reported in any recent tests.

Burbank No. 3: see *Hale*.

Burbank No. 4: see *Heikes*.

9. *Chabot*.—Medium to large, oblong-conical; pink-red in color with many very fine gold dots; flesh yellow and juicy, rather acid, of good quality, cling; medium to late in season; very productive.

Ripe in this latitude early in September.

Imported from Japan by Mr. Chabot, of Berkeley, California, but introduced to the trade by Luther Burbank in 1886. "Especially valuable for drying."—*Burbank*.

10. *Delaware*.—Roundish conical, medium in size, purplish bronze in color with a white bloom; flesh wine-color, juicy, com-

binning many flavors. Trees semi-dwarf, very productive. Catalogued amongst Luther Burbank's novelties, 1893. Said to be a cross of Satsuma and Kelsey.

11. *Engre*.—Said to be a small round, red fruit, ripening early. Tree very vigorous. Little known.

12. *Georgeson* (Hattonkin No. 1).—Medium or above in size, oblong and more or less conical, clear golden yellow and somewhat translucent in texture, with a good yellow flesh, cling; very early, probably the earliest of the yellow varieties.

Imported by H. H. Berger & Co., of San Francisco, and brought to notice chiefly by J. L. Normand, Marksville, La. It is closely allied to Kerr, but averages somewhat larger, is a week or two weeks earlier, is less pointed, and the tree is apparently less productive. Now named for Professor C. C. Georgeson, Manhattan, Kansas, who has published critical studies of Japanese fruits.

13. *Hale* (Burbank No. 3).—Medium in size, globular or slightly flattened, scarcely if at all pointed, rather light bright uniform red; flesh red, firm and sweet, tightly clinging to the pit.

Imported by Luther Burbank in 1885, together with Heikes, which see. Mr. Burbank writes me that he disposed of this and No. 4 after they had fruited in the nursery row, and that he now has no knowledge of them. As they have passed entirely out of his hands, I take the liberty to give them names. Both are very much like Satsuma, but are a few days later and appear to bloom earlier; and they are also less pointed, and somewhat different in leaf. Named for J. H. Hale, a well-known nurseryman and fruit grower of Connecticut and Georgia.

Hattankio: see *Kerr* and *Munson*.

Hattonkin No. 1: see *Georgeson*.

Hattonkin No. 2: see *Kerr*.

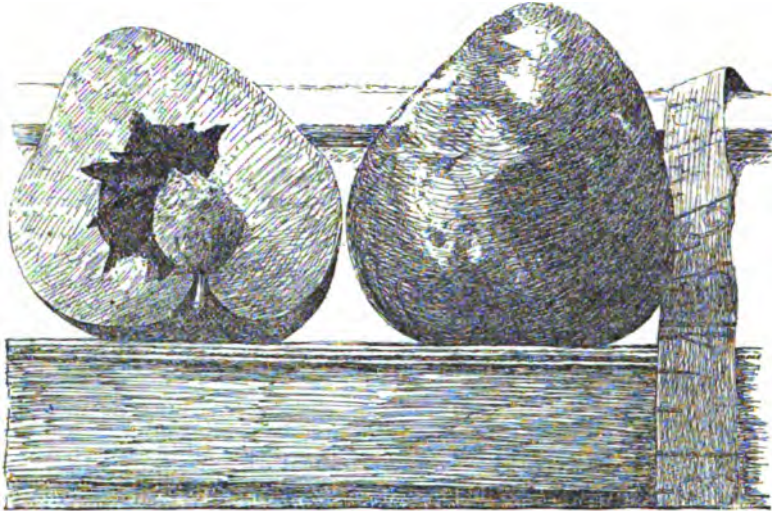
14. *Heikes* (Burbank No. 4).—Much like Hale, but rather more flattened on the ends or oblate, mostly darker in color, the flesh acid.

Named for W. F. Heikes, of the Huntsville Nurseries, Huntsville, Ala. See remarks under Hale, above.

Hytan-Kayo: see *Munson*.

15. *Hoyo Smomo*.—A name used by J. L. Normand, Louisiana. I do not know the fruit.

16. *Kelsey*.—Very large (2–3 in. diam.) and long-pointed, tapering gradually from a heart-shaped base, usually somewhat lop-sided, with a deep furrow-like suture ; color bright red-purple



Kelsey. Three-fourths natural size.

on a yellow ground, more or less marked with dots, very showy ; flesh light yellow and rather firm, rich and pleasant in flavor, free or only slightly clinging to the small stone, more or less hollow.

The first Japanese plum introduced into this country (see page 3), but it did not attract much attention outside of California until about ten years ago. It was figured by Mr. Van Deman in Dept. of Agr. Rept. for 1886, plate X, and again (colored) in Report for 1887, plate I ; also in Wickson's California Fruits, p. 351. Its behavior is not uniform in different years. F. M. Ramsey, of Lampasas, Texas, writes me that in 1888, his Kelsey ripened in September, in 1889 in July, and in 1890 in June. L. A. Berckmans, Georgia, says* that in 1887 the Kelsey did not mature until October 1st ; in 1889 it ripened in July ; in 1890 it "began to ripen the latter part of July and continued for eight weeks," and on October 1st perfectly green specimens were on the trees. I shall expect to learn that under some conditions the tree

* Proc. 14th meeting, Ga. Hort. Soc. (1889) 52.



PLATE I. *Abundance*, grown in New York.



PLATE II. *Willard and Berckmans (Sweet Botan) Plums.*

has a more or less prolonged or continuous habit of bloom. In California the tree is said to be nearly evergreen. The reports as to its hardiness are equally conflicting. I have not yet had good proof that the Kelsey has fruited north of North Carolina. J. Van Lindley says* that last year in North Carolina his Kelsey trees "were loaded with fruit, large and fine, quality of the very best." It ripened from the first to the last of August. "The Kelsey," he continues, "stands at the head for canning and preserving, and sells in any market at fancy prices, but it comes into competition with other fruits grown north." Kelsey has been killed by cold in northern Texas; on the other hand, the trees are said to have come through the winter with little injury in Iowa. My first experience with the Kelsey was at Lansing, Michigan, where the trees killed to the snow line the first winter. Professor Tamari, of Tokio, says that the variety is too tender for the northern plum sections of Japan. Mr. H. E. VanDeman, formerly pomologist of the Department of Agriculture, wrote me upon the hardiness of Kelsey, in 1892, as follows: "My present opinion is that it is about as hardy as the fig. All reliable information that has come to this office up to this date is to the effect that it is not suitable to the northern states because of its tenderness. I know from personal observation that between here [Washington] and Baltimore trees have been seriously injured by winter-killing. Occasionally I have heard of Kelsey plum trees withstanding severe cold, but in every case yet followed up, it has been found that the trees were not correctly named." I am inclined to think, however, that the Kelsey will sometimes endure a New York winter if the wood has been well ripened; but I doubt if it will ever bear in this State.

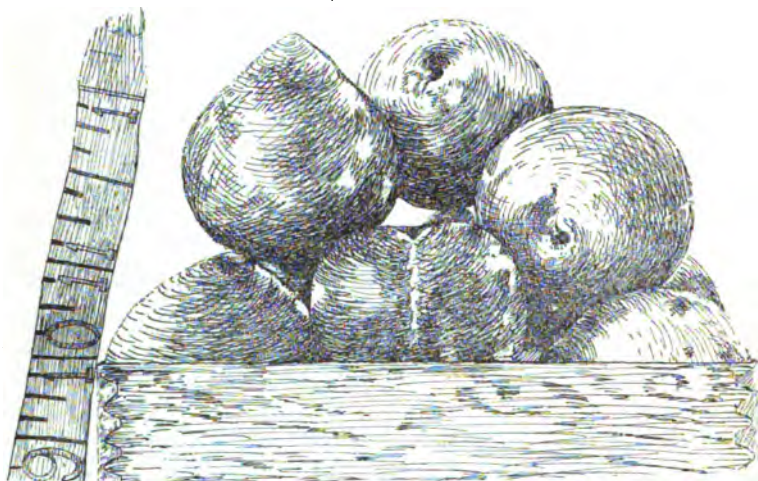
The accompanying engraving of Kelsey, three-fourths natural size, is made from specimens received from Florida.

17. *Kerr* (Hattonkin No. 2. Hattonkin of Berckmans and others).—Medium to large, generally very strongly conical with a deep suture; color orange-yellow, with a creamy bloom; flesh juicy and sweet, good in quality, cling; early.

An excellent variety, but not tested in the north. It varies considerably in shape, even on the same tree, occasional speci-

* Thirteenth Rep. N. Car. Hort. Soc. (1893) 20.

mens occurring without the point. Mr. Berckmans writes me that in 1890 the round form seemed to predominate, while in 1892 the pointed or normal form alone was produced. Imported from Japan by Frost & Burgess, Riverside, California. Now named for J. W. Kerr, of Denton, Maryland, one of the most intelligent plum growers of the central states.



Kerr. Half size.

18. *Late Blood*.—Small, round, dark purple, with red flesh, clingstone, fair in quality, late.

Imported by Luther Burbank in 1888.

19. *Long Fruit*.—Very small, roundish in shape, red, early and said to be a shy bearer. Imported by Luther Burbank in 1885, but very little known.

20. *Maru* (Masu. Massu).—Medium size, round or somewhat flattened; orange-red or vermillion; flesh yellow, of fair quality, free or nearly so; ripens with Berckmans.

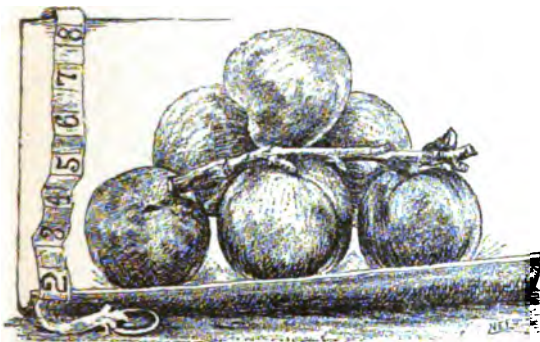
Imported by Luther Burbank in 1885. Commonly called Masu, but erroneously. Maru means *round*. "Coarse and acid with hard lumps, but good canned—about equal to Lombard. Hardier in bud than any other Japanese plum tested here. Bore in 1891 when Abundance and all other Japs., as well as Kieffer

pears, were killed in the bud."—*C. M. Stark, Louisiana, Mo.* Berckmans says that it is sometimes pointed.

21. *Munson* (Hattankio, of Munson, at least in part. Hytan-Kayo of Whitaker, probably).—A large broad-conical fruit, purple or purple-red, with a yellow flesh of excellent quality; freestone or nearly so; medium early and prolific.

J. T. Whitaker, of Tyler, Texas, introduced his Hytan-Kayo in 1886. There seems to be a mixture in this purple Hattankio, for our fruit this year (trees from Munson) was yellow. This is not strange, however, when one considers the utter confusion in which the Japanese plums, and especially the Hattans, have lain. I know of only one purple variety, however, which is commonly called a Hattan or Hattankio, and this is the one which I have here named for Mr. Munson. The Rochester Lithographing Co. has a plate of this plum.

22. *Normand* (Normand Yellow. Normand's Japan).—Medium



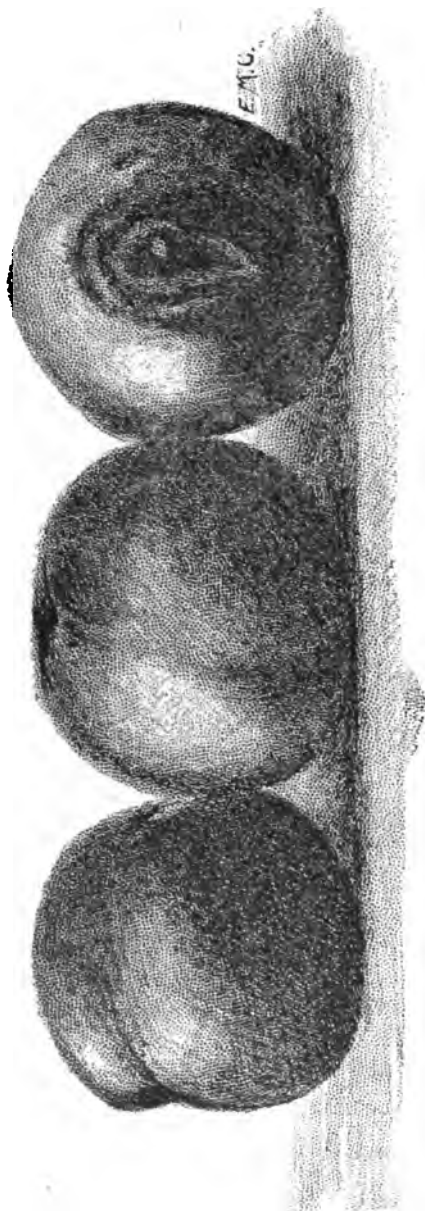
Normand. One-third size.

to large, obtusely conical with a heart-like base and short stem; color clear golden yellow; flesh firm and meaty, yellow, of high quality, free from the small pit. Very prolific, and ripens just after Berckmans and Abund-

ance. Allied to Georgeson and Kerr, but later, and less conical than the latter.

Imported by J. L. Normand, Marksville, La., and by him disseminated under the name of Normand's Japan in 1891. The cut is from specimens grown by Mr. Normand.

23. *Ogon* (Ogan).—Fruits medium in size, flattened at the ends or tomato-shaped, not at all conical, the suture prominent; color clear lemon yellow with a light creamy bloom giving the fruit a whitish appearance; flesh thick and very meaty, not juicy, firm and keeping long, of second or third quality, entirely free from the stone. Tree only moderately productive, or in some



Ogon. Full size. An early yellow freestone plum.

regions even shy. Early, ripening in New York from late July to the middle of August. Excellent for canning.

Imported by H. H. Berger & Co., San Francisco. One of the best known varieties. The illustration shows good specimens natural size.

24. *Orient*. — Large, broadly conical; red, very highly colored; flesh yellow, of high quality. Ripens soon after Burbank. Introduced in the fall of 1893 by Stark Bros., Louisiana, Mo. Figured in *American Gardening* xiv. (1893), p. 363.

25. *Perfection*. — Fruit rather large, oblong-conical, bright carmine with white bloom; flesh fine, firm and sugary, excellent; pit very small; good keeper and very productive. One of Luther Burbank's novelties, '93. Said to be cross of Kelsey with Burbank.

Red June: see *Red Nagate*.

26. *Red Nagate* (Red June. Shiro-Smomo, of some). — Fruits medium,

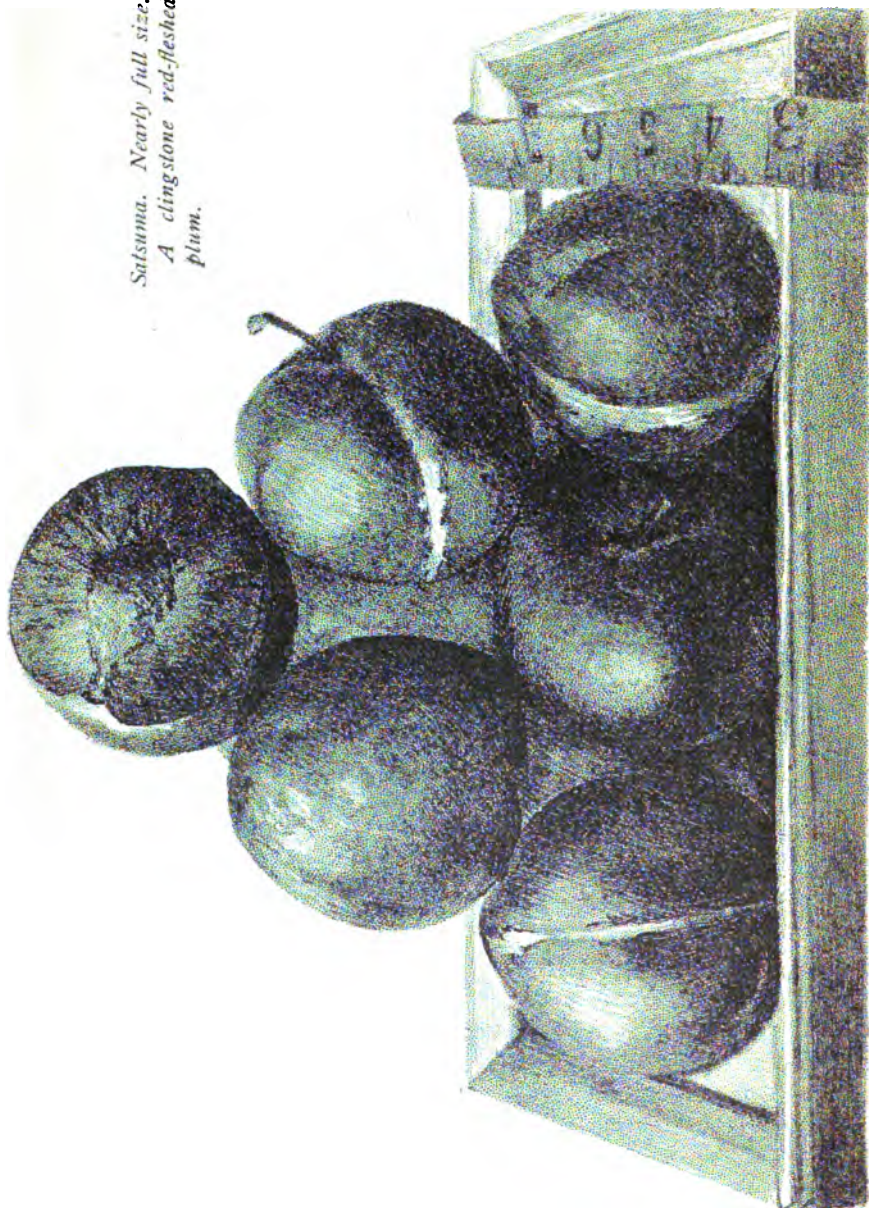
prominently elongated and conical with a well marked suture; color deep red-purple, nearly uniformly distributed; flesh very firm and meaty, yellow, of good quality, cling; very early, ripening with Ogon, and extremely productive, handsome and good.

Imported by H. H. Berger & Co., San Francisco. Stark Bros., Missouri, say that this is the most valuable early Japanese plum they know, being comparatively free from rot and much earlier than Abundance. The nomenclature of the variety here described is much confused. H. H. Berger & Co., write me that the true Japanese Red Nagate has red flesh, which this has not. This is the variety to which the name Shiro Smomo is oftenest applied, but it is neither a Sumomo plum nor is it white (Shiro means *white*), thus affording a curious instance of the utter confusion of the American application of the names of the Japanese plums. Professor Georgeson tells me that the Shiro Sumomo of the Japanese is a small white early plum with yellow flesh, somewhat cling and of medium season. I do not know if it occurs in this country; and it is probably not worth while to endeavor to fit the name to any variety. The Ogon is probably the nearest to it of any variety in this list.

27. *Satsuma* (Blood. Yonemomo).—Size medium to rather large, broadly conical with a blunt, short point, suture very deep; color very dark and dull red all over, with greenish dots and an under-color of brown-red; flesh blood-red, rather coarse and acid, fair to good in quality, tightly clinging to the pit; midseason, productive.

Imported by Luther Burbank in 1886. Figured in Pomologist's Report, Rept. Dept. Agr. 1887, Plate I (colored), and also in Wickson's California Fruits, 351, the latter copied from the former. I have never seen a Satsuma with such a small pit as represented in these cuts, nor of the same shape. The fruit appears to be uniform in shape and markings, and varies little from that shown, nearly natural size, in the engraving on page 30. The Satsuma is hardy in the northern states. Stark Bros., Louisiana, Mo., write that it blooms too early with them and is not so hardy as some others. This belongs to the Beni-Smomo group of the Japanese, which is characterized by red flesh. One of

*Satsuma. Nearly full size.
A clingstone red-fleshed
plum.*



these plums is known in Japan as Yonemomo, and Mr. Berckmans has used the name for this variety; but there is no proof that this particular Satsuma is the Yonemomo of Japan.

Shiro Smomo: see *Red Nagate* and *Berger*.

28. *Shipper*.—Fruit oval, light red with a white bloom; flesh very firm (red?), sweet and juicy; long keeper. Tree sturdy, but a moderate grower. Described with Burbank's Novelties, 1893. Seedling of Satsuma.

29. *Strawberry*.—"Small, round-oblate, red-purple, with a firm, yellow flesh, cling, very early, moderately productive. Earliest sort fruited here,—ripe with the last of the strawberries." *C. M. Stark, Louisiana, Mo.*

There is another and older Strawberry plum, one of the Chickasaws (see p. 31, Bull. 38).

Sweet Botan: see *Berckmans*.

True Sweet Botan: see *Berckmans*.

30. *Uchi-Beni* (Ura-Beni. Honsmomo).—Medium in size, heart-shaped and somewhat pointed, bright carmine-red; flesh red and fine-grained, somewhat acid, rather poor in quality, cling; rather early.

Little known. *Uchi-Beni* means *inside red*.

White-Fleshed Botan: see *Berckmans*.

31. *Willard* (Botan No. 26).—Medium in size, spherical in general outline but prominently cornered or angled, never pointed, the sinus very slight but stem cavity deep; color dark clear red with many minute yellow dots; flesh rather firm, yellow, sweet and of fair quality; freestone. A strong vigorous and hardy tree, productive, and the earliest market Japan plum yet tested in the north, ripening in central New York late in July. In appearance the fruit is remarkably like some of the improved types of *Prunus Americana*. Fruits ripened upon the tree are of pretty good quality, but some which I ripened in-doors were poor.

Cions procured from California six or seven years ago by S. D. Willard, Geneva, N. Y., and named for him by W. F. Heikes in *Practical Nurseryman*, June, 1893. It was probably imported from Japan, but the history of it is lost. The illustration in Plate II shows average specimens, full size.

Yellow-Fleshed Botan: see *Abundance*.

32. *Yellow Japan*.—This name occasionally appears, but I do not know the fruit. Burbank and another red plum have been sold under this name.

33. *Yellow Nagate*.—Unknown to me.

Yonemomo: see *Satsuma*.

34. *Yosebe* (Yosobe).—Small, conical, with a distinct suture, reddish purple in color, the yellow flesh soft and good; pit free or very nearly so; very early, ripening before the Ogon. Tree rather dwarf, with leaves comparatively small and rugose and very prominently serrate, yellowish green in color, and conduplicate or trough-shaped as they hang upon the tree. Twigs reddish.

Imported by H. H. Berger & Co. Too small to be very valuable, unless for its earliness.

Luther Burbank catalogues amongst his novelties of 1893, an unnamed purple-leaved seedling of Kelsey; Golden, said to be a cross of Robinson (Chickasaw) and Sweet Botan; Juicy, of same parentage; an unnamed variety, said to be a cross of Botan by Robinson; and an unnamed cross of Kelsey by Satsuma.

Weaknesses and Diseases.—Undoubtedly one of the most serious weaknesses of the Japanese plums is their very early season of bloom. This is particularly noticeable in the middle and southern states, where the buds are ready to burst with the very first warm days of spring. In the north, where the soil is colder and the unseasonable "warm spells" are of comparatively short duration, this tendency to early bloom is less marked. Yet some of the Japanese varieties seem to be especially given to early awakening in the spring. I have not heard of serious trouble in this respect in New York, but many of the varieties are not yet bearing in this state. The following records of habitual injury from spring frosts have been received from correspondents:

VARIETIES LIABLE TO INJURY BY SPRING FROSTS.

Observer.	Varieties injured.
J. T. Lovett, Little Silver, Monmouth Co., N. J.	Abundance, Burbank, Kelsey, Ogon, Satsuma.
J. W. Kerr, Denton, Carolina Co., Md.,	Botankio (Babcock?), Burbank, Chabot, Kelsey.
J. S. Breece, Fayetteville, Cumberland Co., N. C.	Kelsey, Satsuma.
J. L. Normand, Marksville, Avoyelles Co., La.	Satsuma.
Stark Bros., Louisiana, Pike Co., Mo.,	Kelsey, Satsuma.

T. V. Munson, Denison, Grayson Co., Tex.,	Botankio (Babcock?) Munson, Kelsey, Red Nagate.
J. T. Whitaker, Tyler, Smith Co., Tex.,	Kelsey.
F. M. Ramsey, Lampasas, Lampasas Co., Tex.,	Kelsey.
A. M. Ramsey & Son, Mahonet, Burnet Co., Tex.,	Kelsey.
H. M. Stringfellow, Hitchcock, Polk Co., Tex.,	Kelsey.
G. Onderdonk, Nursery, Victoria Co., Tex.,	Kelsey, Satsuma.

The following record of the actual dates of blooming of the Japanese plums has been prepared for me by J. W. Kerr, of the Chesapeake peninsula. It will be seen that some of them bloom as early as *Pissardii* and *Simonii*, which are known as very early bloomers.

RECORD OF DATES AT WHICH ORIENTAL PLUMS BLOOMED AT
EASTERN SHORE NURSERIES, DENTON, CAROLINE CO.,
MD., 1892.

Variety.	Date when first open blossom appeared.	Date when half of buds were open.	Date when all, or nearly all were out.
Kelsey	Apr. 7	Apr. 15	Apr. 20
Botan	" 6	" 12	" 18
Ogon	" 16	" 18	" 24
Maru	" 8	" 16	" 22
Chabot	" 8	" 15	" 19
Botankio	" 4	" 8	" 10
Hattankio	" 10	" 15	" 19
Yosebe	" 16	" 18	" 24
Uchi-Beni	" 16	" 18	" 20
Shiro Smomo	" 14	" 16	" 19
Long Fruit	" 16	" 18	" 20
Yellow Japan	" 16	" 18	" 20
Burbank	" 7	" 11	" 16
Satsuma	" 7	" 10	" 17
Engre	" 15	" 17	" 20
<i>Pissardii</i>	" 7	" 9	" 14
<i>Simonii</i>	" 5	" 9	" 14

Some, at least, of the Japanese plums are much subject to fruit-rot, and this appears to be specially true of the Abundance, particularly when it is not well thinned. Mr. Kerr writes me under date of July 5, 1892, that "there is not a single variety of the Japanese plums that is holding its fruit, except Botan, and even they are rotting very rapidly and I doubt if a perfect specimen will go through. Bordeaux mixture seems to avail nothing

as a remedy for the rot. Notwithstanding failures in general this year, I have begun shipping Chickasaws, of which I have a good crop." These plums are evidently not more subject to rot than many varieties of Domesticas, however, and I doubt if they are so much injured, as a rule, as the Lombard.

It has been said that these plums, or some of them, are curculio proof; but this is an error. Yet they often appear to escape much of the excessive injury which falls to the *Domestica* varieties. The following note from the *Rural New-Yorker* bears upon this point. I saw the tree here described, upon the editor's grounds, just before the fruit was ripe, and it appeared to be free from curculio injury:

"The Abundance plum (August 4) at the Rural grounds is a sight to behold. The branches are wreaths of fruit, and they, as well as the tree itself, are held up by props and ropes. Some of the plums are beginning to color; all are of good size, and, though the old marks of the curculio sting are engraved upon most of them, no injury seems as yet to have resulted. For twenty years, off and on, the *Rural New-Yorker* has tried so-called curculio proof plums. We have never used insecticides nor jarred the trees to destroy them, and we have never before had a crop of plums. Plums are not raised in the vicinity simply because the people are not willing to put themselves to the trouble of jarring the trees, and they know from experience that they cannot raise plums without doing so. Now here we have the Abundance loaded down with beautiful fruit, while not a precaution has been taken to destroy the curculio. Blessed be the Abundance! It is well named."

So far as I have been able to learn, none of the varieties are seriously attacked by black-knot, although the disease occurs on them. This circumstance, however, should not be dwelt upon too strongly, for it is possible that the exemption is largely accidental. Yet I have seen perfectly healthy trees on the Hudson River where all the common plums in the neighborhood were seriously injured. The varieties appear to be nearly exempt from leaf-blight, also.

The Japanese plums are commonly budded upon the peach, and so far very few complaints have reached me from failure of the union; but I shall be surprised if as strong and permanent results

come from the use of this stock as from the use of their own seedlings or *Domestica* stocks.

REVIEW.

1. Twenty-four years ago a plum was introduced into California from Japan which proved to belong to a species heretofore unknown in America. It was first fruited by the late John Kelsey, of Berkeley, California, and for him it was named. It began to attract wide attention about ten years ago.

2. This plum belongs to the species *Prunus triflora*, which is supposed to be native to China, but which is unknown in a wild state. Subsequent importations have been made from Japan, and at the present time about thirty varieties are more or less known and disseminated.

3. These Japanese plums are distinguished from the common *Domestica* plums by their generally more pointed or heart-shaped fruit which has a deep groove or suture upon one side, by a longer-keeping flesh and generally a less winged pit. In other botanical features they differ in commonly bearing three or more winter buds at a joint, instead of one, in the light colored rough bark, flowers usually in twos or threes, leaves long-obovate or elliptic and finely serrate. They are closely allied in botanical characters to some types of native plums.

4. The nomenclature of the varieties is much confused, largely because the Japanese names are used for groups or classes and not for specific varieties; and there is no uniformity even in the generic application of these names. It is essential to an exact understanding of this fruit, therefore, that the Japanese class-names be discarded in this country.

5. While importations from Japan have been made freely, there are probably many more good varieties in that country which have not reached America; but we must look for most permanent progress in the future from American offspring.

6. The Japanese plums differ amongst themselves greatly in hardiness. The Kelsey is adapted only to the states south of Virginia and to the warmer parts of the Pacific Coast, but other varieties are fully hardy in parts of Connecticut, Ontario, New York and Iowa.

7. The varieties now known to be hardy in the plum regions of New York are Burbank, Abundance, Willard, Ogon, Satsuma, Chabot, Yosebe and Berger; and others give promise of being as hardy as these.

8. The period of ripening of the various kinds extends over a long season, running, in New York, from the middle of July to the middle of September. The same variety does not always appear to ripen at the same period in successive years. This is especially true of the Kelsey, which sometimes varies through a period of three months. In New York, the earliest market variety which has been tested appears to be Willard, followed closely by Ogon, then Abundance and Berckmans, and Burbank still later. Kelsey is generally the latest of all the varieties.

9. Most of the Japanese plums keep for several days, and some of them even for two weeks, after they are ripe. Satsuma is one of the best keepers known in the north.

10. The larger part of the varieties are red with deep yellow flesh, and the Satsuma, and a few varieties less known, have deep red flesh. There are only four well known yellow varieties. There are eight freestones, as follows: Ogon, Willard, Kelsey, Berger, Maru, Munson, Normand, Yosebe.

11. The varieties which can be most confidently recommended at the present time are Abundance, Burbank, Willard, Kerr, Berckmans, Maru, Red Nagate, Chabot, Satsuma and perhaps Ogon. Kelsey is recommended for the south.

12. The chief weaknesses of the Japanese plums are too early bloom of some varieties and liability to the fruit-rot fungus. Amongst their advantages are partial immunity from black-knot, and leaf-blight and often a partial freedom from curculio injury.

13. Altogether, the Japanese plums constitute the most important type of fruit introduced into North America during the last quarter of a century, and they should receive careful tests in all parts of the country.

L. H. BAILEY.

30.011
N7
C8eb

Bulletin 63.

March, 1894.



Cornell University Agricultural Experiment Station.

AGRICULTURAL DIVISION.

Co-operative Test of Sugar Beets.

— BY —

I. P. ROBERTS.

=====

PUBLISHED BY THE UNIVERSITY.

ITHACA, N. Y.

1894.

ORGANIZATION.

BOARD OF CONTROL: THE TRUSTEES OF THE UNIVERSITY.

STATION COUNCIL.

President, JACOB GOULD SCHURMAN.

Hon. A. D. WHITE,	-	-	-	-	Trustee of the University.
HON. JOHN B. DUTCHER,	-	-	-	-	President State Agricultural Society.
I. P. ROBERTS,	-	-	-	-	Professor of Agriculture.
G. C. CALDWELL,	-	-	-	-	Professor of Chemistry.
JAMES LAW,	-	-	-	-	Professor of Veterinary Science.
A. N. PRENTISS,	-	-	-	-	Professor of Botany.
J. H. COMSTOCK,	-	-	-	-	Professor of Entomology.
L. H. BAILEY,	-	-	-	-	Professor of Horticulture.
H. H. WING,	-	-	-	-	Asst. Professor of Dairy Husbandry.
G. F. ATKINSON,	-	-	-	-	Asst. Professor of Cryptogamic Botany.

OFFICERS OF THE STATION.

I. P. ROBERTS,	-	-	-	-	Director.
HENRY H. WING,	-	-	-	-	Deputy Director and Secretary.
E. L. WILLIAMS,	-	-	-	-	Treasurer.

ASSISTANTS.

M. V. SLINGERLAND,	-	-	-	-	Entomology.
GEO. C. WATSON,	-	-	-	-	Agriculture.
G. W. CAVANAUGH,	-	-	-	-	Chemistry.
E. G. LODEMAN,	-	-	-	-	Horticulture.

Offices of the Director and Deputy Director, 20 Morrill Hall.

Those desiring this Bulletin sent to friends will please send us the names of the parties.

BULLETINS OF 1894.

62. The Japanese Plums in North America.
63. Co-operative Test of Sugar Beets.

CO-OPERATIVE TEST OF SUGAR BEETS.

In the Spring of 1893 the Station received a quantity of sugar beet seed from the Agricultural Department, Washington, D. C. This seed was sent to seventy representative farmers of the state, with the request that they co-operate with us in a test of growing sugar beets, and that a sample of a half dozen average beets be sent us in the Fall for analysis. Later in the season blanks of the form indicated below were sent out with the request that they be filled out and returned with the sample of beets at the time of harvesting :

Previous crop

Kind of soil

Date of planting

Date of harvesting

Distance of rows apart

Weight of trimmed beets from one row two rods long

Kind and amount of fertilizers applied

Name of grower

Post Office

County

The samples of seed were sent with the idea of distributing them over the entire state as much as possible and consequently were sent into fifty-one counties. Of the seventy farmers receiving seed thirty-one responded by sending us more or less data concerning the growth of the beets. The majority, however, sent all the data asked of them and thirty sent samples for analysis. The following table gives the names of the growers, their addresses, the yield per acre, the per cent. of sugar in the beets, arranged alphabetically according to the county where grown :

TABLE I.

No.	County.	Name of grower.	Post Office.	Yield per acre in tons.	Per cent. of sugar in beets.
1	Broome	C. W. Wright	Ouaquaga	22.00	12.10
2	Cayuga	H. C. Bush	Mapleton		13.40
3	Cayuga	E. R. Rowland	Five Corners	27.72	14.43
4	Chemung	C. A. Lowe	Big Flats		13.14
5	Clinton	Thos. Armstrong	Plattsburg		13.98
6	Columbia	Geo. T. Powell	Ghent	23.32	14.66
7	Delaware	A. O. Potter	Franklin	11.30	11.52
8	Erie	B. J. Cole	Willink	32.24	12.88
9	Genesee	F. E. Ford	Elba	21.12	12.51
10	Greene	B. H. Bedell	Medway	15.67	13.14
11	Niagara	W. J. Hall	Youngstown		11.87
12	Onondaga	B. H. Devendorf	Cicero	44.00	13.48
13	Ontario	J. J. Mc Namara	Reeds Corners	20.52	13.19
14	Orange	Henry Bull	Stony Ford	12.40	12.65
15	Otsego	W. S. Moore	Mt. Upton		12.65
16	Putnam	C. H. Royce	Garrisons	34.79	
17	St. Lawrence	G. C. Mc Ewen	Lawrenceville	36.03	12.87
18	Saratoga	J. I. Parent	Birchton	8.12	11.80
19	Schuyler	C. D. Smead	Logan	19.99	14.36
20	Schuyler	J. W. Corbett	Watkins	31.18	11.18
21	Steuben	E. E. Wood	Campbell		10.00
22	Suffolk	C. W. Wickham	Mattituck	47.25	9.16
23	Tompkins	Cornell University	Ithaca	7.05	14.71
24	Tompkins	Cornell University	Ithaca	10.07	12.20
25	Tompkins	Cornell University	Ithaca	11.905	13.69
26	Tompkins	F. P. Hatch	Dryden	15.84	12.27
27	Tompkins	King & Robinson	Trumansburg	31.18	13.43
28	Tompkins	H. C. Mc Lallen	Trumansburg	19.14	13.62
29	Wayne	J. C. Baird	Clyde	23.76	
30	Wayne	W. S. Blakeman	Clyde	22.88	12.46
31	Westchester	F. Q. White	Yorktown	26.40	13.75

Most of the blanks, from which the above table was compiled, were completely and properly made out, and with few exceptions the samples of beets were received in a fairly fresh condition. It is readily seen that there is always more or less danger of inaccuracies occurring from this source, where the beets are sent a considerable distance and allowed to become somewhat dried or wilted before reaching the chemist. A comparatively slight drying might reduce the water content of the beet, and so apparently increase the percentage of sugar that the error from this source alone might indicate a profitable yield of sugar, while in reality the reverse had existed. The danger of error from this source was fully realized and consequently the samples were ordered to be sent by express and were placed in the hands of the chemist at the earliest moment.

Chemist Harvey W. Wiley, of the Department of Agriculture, in his report to the Secretary of Agriculture, on experiments with Sugar Beets published in Bulletin No. 33 says: "We are accustomed to look with suspicion upon any yield of sugar beets which exceeds 25 tons per acre. While it is not impossible to secure a higher yield than this of good saccharine quality, yet it is so rare as to throw doubt upon miscellaneous data showing an excess of that yield." In studying the yields per acre in the above tables, it must be borne in mind that in many cases the seed was sown in small quantities in gardens, and given wholly hand culture. That this condition of affairs existed was evident from the statement that the seed in some cases was planted in gardens in rows too near together to admit of horse cultivation.

While the results in these do not give a correct idea of what might be expected on the same kind of soil from a more extended cultivation in a practical way, they may serve a useful purpose in showing what can be accomplished in the way of securing large yields of beets per acre.

Had the seed been sent out earlier, undoubtedly better results would have been reported, but as the samples were received from Washington at so late a date that the farmers could not be notified that samples would be sent them, the first knowledge they had of the request to co-operate with us was with the receipt of the seed. Many had already planted or sowed to other crops their land, that was at all suitable to the cultivation of beets, and consequently many samples of seed were not sowed at all, and many others that were sowed failed to germinate.

The fact that so many samples of seed failed to germinate was probably due to their being sowed on poorly fitted land not suited to the cultivation of the beet and to the drought which was quite general throughout the state from May until August. For convenience of study the foregoing table is re-arranged into three tables according to varieties, and also into three tables according to the kind of soil in which the beets were grown.

TABLE II.—DIPPES KLEINWANZLEBENER.

No.	Yield per acre in tons.	Average weight of beets in ozs.	Per cent. sugar.
1	22.00	39.24	12.10
5	—	64.60	13.98
9	21.12	32.91	12.51
12	44.00	65.46	13.48
18	8.12	22.12	11.80
19	19.99	35.21	14.36
24	10.07	37.08	12.20
30	22.88	25.47	12.46
Average	21.48	40.26	12.86

TABLE III.—KNAUERS IMPERIAL.

No.	Yield per acre in tons.	Average weight of beets in ozs.	Per cent. sugar.
3	27.72	35.75	14.43
4	—	30.73	13.14
8	32.24	34.75	12.88
13	20.52	65.77	13.19
14	12.40	28.39	12.65
17	36.03	29.03	12.87
20	31.18	41.06	11.18
22	47.25	44.07	9.16
21	—	84.75	10.00
25	11.905	13.72	13.69
28	19.14	35.26	13.62
29	23.76	—	—
31	26.40	27.02	13.75
Average	26.19	69.55	12.49

TABLE IV.—VILMORENS RICHEST.

No.	Yield per acre in tons.	Average weight of beets in ozs.	Per cent. sugar.
2	—	36.21	13.40
6	23.32	27.16	14.66
7	11.30	22.04	11.52
10	15.67	26.65	13.14
15	—	54.37	12.65
23	7.05	33.70	14.71
26	15.84	40.50	12.27
Average	14.68	84.87	18.19

TABLE V.—ON CLAY SOIL.

No.	Yield per acre in tons	Average weight of beets in ozs.	Per cent. sugar.	Variety.
1	22.	39.24	12.10	Dipp. Klein
23	7.05	33.70	14.71	Vil. Richest
24	10.07	37.08	12.20	Dipp. Klein
25	11.90	35.26	13.69	Knauers Imp.
21	—	13.72	10.00	Knauers Imp.
Average	12.77	31.80	12.54	

TABLE VI.—CLAY LOAM.

No.	Yield per acre in tons.	Average weight of beets in ozs.	Percent. sugar.	Variety.
4			13.14	Knauers Imperial
9	21.12	32.91	12.51	Dippes Kleinwanzlebener
13	20.52	28.39	13.91	Knauers Imperial
14	12.40	29.03	12.65	Knauers Imperial
17	36.03	41.06	12.87	Knauers Imperial
18	8.12	22.12	11.80	Dippes Kleinwanzlebener
19	19.99	35.21	14.36	Dippes Kleinwanzlebener
27	31.18	44.67	13.43	Knauers Imperial
29	23.76			Dippes Kleinwanzlebener
30	22.88	25.47	12.46	Dippes Kleinwanzlebener
31	26.40	27.02	13.75	Knauers Imperial
Average	22.24	31.76	13.08	

TABLE VII.—SANDY LOAM AND GRAVEL.

No.	Yield per acre in tons.	Average weight of beets in ozs.	Per cent. sugar.	Variety.
3	27.72	35.75	14.43	Knauers Imperial
6	23.32	27.16	14.66	Vilmorens Richest
7	11.30	22.04	11.52	" "
8	32.24	34.75	12.88	Knauers Imperial
10	15.67	26.65	13.14	Vilmorens Richest
11		65.77	11.87	Knauers Imperial
12	44.00	65.46	13.48	Dippes Kleinwanzlebener
15		54.37	12.65	Vilmorens Richest
20	31.18	44.07	11.18	Knauers Imperial
22	47.25	84.75	9.16	" "
28	19.14	43.84	13.62	" "
Average	27.98	45.87	12.60	

The numbers in the left hand column of these tables correspond with those of the left hand column of Table I, and are given to enable the reader to determine in what part of the State the different varieties were grown.

It will be noticed that there was less difference in the per cent. of sugar in the beets from the different soils than there was from the different varieties of beets. The average per cent. of sugar of the varieties grown on clay soil was lower than the average of the varieties grown on other soils. That from clay soil being 12.54 while the average percentage of sugar from sandy loam and clay loam were 12.60 and 13.08 respectively. It is true that the number of trials, on the different kinds of soil were not sufficient to make this comparison of great value, yet we cannot pass it by as unworthy of notice.

In Bulletin No. 30 of the U. S. Department of Agriculture, Mr.

Wiley says,—“For the purpose of fixing a standard of comparison I would say that the typical sugar beet for sugar making purposes should weigh 600 grammes, contain 14 per cent. of sugar and have a purity of at least 80. With such raw material at his command in sufficient quantities, the manufacturer cannot fail of success, provided he be supplied with the latest and most improved forms of machinery; in general it has been found that when beets exceed 600 grammes in weight it is difficult to maintain their sugar content at a high standard.”

The average weight of all the beets received for analysis in this test was 830 grammes and the average per cent. of sugar of all samples was 12.90. From the above quotation, it would be expected that the percentage of sugar in these beets would fall below the assumed standard of 14 per cent. for no other reason than that the beets were too large for the highest per cent. of sugar. When we calculate the percentage of sugar in a crop from a few sample beets selected at random it is readily seen that the accuracy of this method is somewhat doubtful to say the least as it is almost impossible, without great labor and skill, to select three or four beets that will represent with a considerable degree of accuracy the sugar content and average weight of a crop of beets. We would expect that the samples sent for analysis would be rather larger than the average of the whole crop, and so we feel safe in assuming that the per cent. of sugar in all the beets grown in this test would be fully equal if not greater than that shown by the average of the analysis. We intend to carry on this test another year in a more extended way and will gladly furnish seed free to farmers of this State who will co-operate with us in carrying on this work. We would like to correspond with those who are willing to participate in this test that we may make arrangements to send them the quantity of seed of such varieties as they desire to plant.

I. P. ROBERTS.

1-17 1900



Bulletin 64.

March, 1894.

Cornell University Agricultural Experiment Station.

ENTOMOLOGICAL DIVISION.

ON CERTAIN
Grass-Eating Insects.



By EPHRAIM PORTER FELT.

PUBLISHED BY THE UNIVERSITY.

ITHACA, N. Y.

1894.

ORGANIZATION.

BOARD OF CONTROL: THE TRUSTEES OF THE UNIVERSITY.

STATION COUNCIL.

President, JACOB GOULD SCHURMAN.

HON. A. D. WHITE,	-	-	-	-	Trustee of the University.
HON. JOHN B. DUTCHER,	-	-	-	-	President State Agricultural Society.
I. P. ROBERTS,	-	-	-	-	Professor of Agriculture.
G. C. CALDWELL,	-	-	-	-	Professor of Chemistry.
JAMES LAW,	-	-	-	-	Professor of Veterinary Science.
A. N. PRENTISS,	-	-	-	-	Professor of Botany.
J. H. COMSTOCK,	-	-	-	-	Professor of Entomology.
L. H. BAILEY,	-	-	-	-	Professor of Horticulture.
H. H. WING,	-	-	-	-	Asst. Professor of Dairy Husbandry.
G. F. ATKINSON,	-	-	-	-	Asst. Professor of Cryptogamic Botany.

OFFICERS OF THE STATION.

I. P. ROBERTS,	-	-	-	-	Director.
HENRY H. WING,	-	-	-	-	Deputy Director and Secretary.
E. L. WILLIAMS,	-	-	-	-	Treasurer.

ASSISTANTS.

M. V. SLINGERLAND,	-	-	-	-	Entomology.
GEO. C. WATSON,	-	-	-	-	Agriculture.
G. W. CAVANAUGH,	-	-	-	-	Chemistry.
E. G. LODEMAN,	-	-	-	-	Horticulture.

Offices of the Director and Deputy Director, 20 Morrill Hall.

Those desiring this Bulletin sent to friends will please send us the names of the parties.

BULLETINS OF 1894.

62. The Japanese Plums in North America.
63. Co-operative Test of Sugar Beets.
64. On Certain Grass-Eating Insects.

ON CERTAIN GRASS-EATING INSECTS.

A SYNOPSIS OF THE SPECIES OF CRAMBUS OF THE ITHACA FAUNA.

A Thesis in Entomology.

BY EPHRAIM PORTER FELT, B. S., FELLOW IN ENTOMOLOGY IN CORNELL
UNIVERSITY.

INTRODUCTION.

There abound in every pasture and meadow certain small moths that may be easily recognized by a peculiar habit of closely folding their wings about the body when at rest. (Fig. 1.) On account of this habit these moths have received the popular name of Close-wings; the technical name of the genus is *Crambus*.



FIG. 1.—*Crambus
alboclavellus*.

It is only necessary to walk through the grass in the afternoon or early evening to observe these moths in their native haunts; they start up on every side, fly a short way and alight. At times the grass seems to be alive with them.

Like some other common insects, these moths have received little attention from agriculturists, although they are really of considerable economic importance. In the larval state they are grass-eating caterpillars; and as they are very abundant they can hardly fail to materially lessen the crop of hay or the amount of available food in a pasture.

Under ordinary circumstances the injury caused by these insects attracts but little attention. But these innocent appearing moths have been known to cause the complete devastation of large areas, whole townships being affected. Each year adds to the recorded instances where they have seriously injured culti-

vated crops. Therefore it seems important that our knowledge of them be increased and that it be made easily accessible.

This paper has been prepared as a contribution to such knowledge. The investigation upon which it is based was carried on in the insectary of the Cornell University Experiment Station, and I have been allowed the free use of the entomological collection of the University. The scope of this paper has been somewhat broadened by the addition of figures and discussions of several species not yet found in the Ithaca fauna, kindly given me by Rev. Geo. D. Hulst. These are those numbered 4, 6, 7, 13, 17, 23 and 27. I am indebted to Dr. C. H. Fernald for the determination of several species; to Samuel Henshaw for the privilege of examining the collection of *Crambus* in the museum of Harvard University and in the museum of the Boston Society of Natural History; and also to Mr. Wm. Beutenmüller for an opportunity of examining the collection of the late Henry Edwards.

The genus *Crambus* is world-wide in distribution; species having been described from widely separated countries of each continent and from a number of the larger islands. Over sixty North American species have been catalogued. In Ithaca twenty species occur and, judging from the recorded distribution, this may be regarded as nearly the average number of species that might occur in any one locality on this continent. The various species resemble each other so closely that the characters of almost any species would enable even a non-scientific man to refer the others to this genus.

GENERAL CHARACTERISTICS.—Among grass insects Crambids may be recognized by their peculiar habit of folding the wings partially around the abdomen.* The moths are rather small, slender creatures, with very long snout-like palpi. (Fig. 2.) From their long snout-like palpi they, with many others, have been termed Snout Moths. The larger species are about half an inch long and with wings that spread about an inch. The fore wing often presents pretty designs in silver, gold, yellow, brown, black and white or they may be of a nearly unbroken somber color. The hind wings are usually a white or grayish color. Both fore and hind wings are ornamented with



FIG. 2.—
Labial
Palps. *C.*
vulgivaga-
ellus,
enlarged.

* In two seasons collecting I have failed to see any similar moths in the grass with this habit.

delicate fringes on the outer margins. The fringes usually have a metallic luster. The antennæ are nearly as long as the body and very slender. The male antennæ are the stouter (Pl. IX, Fig. 18). The eggs of the various species exhibit great uniformity (Pl. XII). They are more or less oval, and have ten to twenty longitudinal ridges and numerous smaller transverse ridges. When first laid the eggs are nearly white, but before hatching they change to a more or less reddish color and in one species they become bright scarlet. The larvæ are about one twenty-fourth of an inch long when first hatched. They usually have dark colored heads and a straw colored body with rows of dark colored tubercles. Upon the head and tubercles small hairs occur. In the different stages of growth the larvæ change in size and depth of coloring, the whole body usually becoming much darker. When full grown the larvæ are from one to two inches long.

HABITS.—Members of this genus fly mostly on dull afternoons and during the early evening. They frequent open fields and the borders of woods. When disturbed the moths rarely fly more than two or three rods at a time. They alight with a peculiar swoop upon a dried stalk of grass, with their heads usually down. These insects dislike a horizontal position very much and will fly some time rather than light upon a flat surface. When at rest upon a stalk of grass the moths are rather difficult to see, as their color harmonizes with their surroundings. So far as is known most of the species live upon grass, including under this term

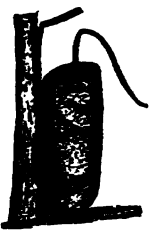


FIG. 3. — Nest of larva. *C. interminellus*, enlarged.

corn, oats, and wheat. Some species may live upon sedges and other coarse grass-like plants. The eggs are usually, if not always, allowed to fall at random in the grass. They hatch in from ten to twenty days. The young larvæ live in cylindrical web-lined nests (Fig. 3.) the outside of which is covered with bits of grass or particles of soil. The nests are usually perpendicular and at or just below the surface of the soil. The larvæ (Fig. 4) feed mostly in the early evening. Some larvæ cut off the blades of grass and draw the end down into the nest so they can feed without leaving the nest. In the early fall the larvæ close the tops of their nests before going into

hibernation. In the spring they come forth, complete their growth, pupate near the surface, and later the adults emerge.

ECONOMIC IMPORTANCE. — Though the various species of *Crambus* are common, they have rarely attracted much attention as destructive insects. This is due to their insidious methods of work. Unless the damage they do is very serious it is hardly noticed or, if noticed, attributed to other causes. As the larvæ live a retired life close to the surface, eating mostly at night and remaining in their nests during the day, they are rarely seen. Like most larvæ they feed most voraciously just as they are completing their growth; consequently, when the damage is noticed most of the larvæ are hidden in their retreats where they pupate. In these places none but an experienced entomologist would find them, or would think of associating the damage done with the harmless appearing moths that fly later.



FIG. 4.—Larva. *C. albellus*, enlarged.

Hardly any farmer would think seriously of the loss of only one stalk of grass in ten, yet the aggregate for the country at large would be enormous. Not only is the damage to a crop where nothing short of a serious injury would attract attention, but the damage is distributed throughout the growing season. As a general rule each species is most destructive at a different time from the other species of that locality; hence, species of *Crambus* prey upon the grass as a succession of small armies. Could the loss caused by these species come at one time in the year their destructive power would be better appreciated. Less than a third of the species may be classed as of economic importance, but these possess a capacity to cause almost infinite loss if the conditions are favorable.

In 1880 and 1881 the conditions were favorable for the development of several species of Close Wings. The Vagabond Crambus (*C. vulgivagellus*) was the chief offender, though the Dried Crambus (*C. interminellus*) was associated with the former in the devastation. In the latter part of May, 1881, Dr. Lintner was notified of a "formidable invasion of the grass lands of St. Lawrence County, N. Y., by the army worm." He writes: "The ravages had only been observed during the preceding ten days, but already had they reached such magnitude that many

extensive pastures had been completely ruined. The entire destruction of both the pastures and meadows was threatened, and serious detriment to the important dairy interests of the northern counties of the State was anticipated. Hundreds of acres of pasturage in the town of Potsdam had been destroyed, and not a single farm, it was believed, had escaped attack. An upland pasture, containing fifty acres, which, ten days previous to my visit, had afforded good pasturage, was now entirely brown. No grass could be seen in glancing over its whole extent, except a narrow strip which had been used as a roadway when farming purposes necessitated occasional passing from one field to another. This from some unknown reason had remained green." Fortunately, such destructiveness seems to be the exception, though there are a number of species almost as common and as prolific as the Vagabond Crambus.

In 1885, Forbes, in the 14th Report on the Insects of Illinois, records the destruction of corn by the Corn Root Worm (*C. zeel- lus*). In 1891, L. Bruner reports the same insect injuring corn in Nebraska and several other states. The Vagabond Crambus is also charged with injuring small grains. In Bulletin 14 of the Delaware Experiment Station for December, 1891, the Sooty Crambus (*C. caliginosellus*) is reported injuring corn in that section, the injury having been noticed as early as 1886 at Bennings, Md. In the Annual Report of the Maine State College and Experiment Station for 1891 a species of *Crambus* is charged with injuring the apple in the same manner as the Codlin Moth. Prof. Munson writes: "In many cases the casual observer would attribute the injury to the Codlin Moth, when in reality it is due to another insect—a species of *Crambus*. The larva of this moth is smaller than the Codlin Moth and works only in the calyx. This insect was quite abundant the past season."

Though the various species of *Crambus* are reported as damaging cultivated crops to a considerable extent, yet in most cases it is the result of unusual conditions. The moths are grass insects and incline to remain in the pastures and meadows. The larvæ are also inclined to remain in or near one place. If cultivated fields are near grass lands the moths will fly into them more or less and drop eggs wherever they fly; these eggs hatch and the larvæ seek food. Again, if grass land is plowed there are more

or less of these larvæ seeking food. In either case if the larvæ can feed upon the crop planted, it does, and loss must follow. This seems to be the way most of the cultivated crops are injured. In some cases these insects seem to have become established in the field, but in the majority of cases the greatest injury is on the edges of the field near grass land. In view of these facts it is hardly probable that members of this genus will ever become serious pests in cultivated fields.

PREVENTIVE MEASURES.—In the egg and early larval state these insects seem very susceptible to unfavorable conditions. In most cases climatic conditions or insect enemies may be depended upon to keep these small pests in check. When natural forces prove inefficient, recourse must be had to artificial means.

I know of no experiments in combating these pests, and but little has been suggested. The principal contribution to this phase of the subject was made by Dr. Lintner in his First Report as State Entomologist.

Burning.—This was recommended in the late fall or early spring in order to destroy the larvæ while hibernating. Some species hibernate above ground and upon these it would be very effective.

Applications of ashes, lime, gas lime, plaster, dust, etc.—A trial of these substances was recommended, but there is no record of their being used.

Rolling the ground.—This was advised on limited areas.

Trap-lanterns.—An examination of the record of any species taken in the trap-lanterns near the Cornell insectary during the years of 1889 or 1892 will show that the greater number taken were males, except *C. laqueatellus* where the females were in excess. If we accept the strong probability that one male can fertilize* several females, the trap-lantern is of little value. In the case of *C. laqueatellus* the females were examined and only one was found with an abdomen distended with eggs. The females fly but little before most of their eggs are laid, consequently the trap-lantern as a practicable means of checking the

*In the summer of 1891 the writer observed a male Gypsy Moth (*Ocnieria dispar*) copulate successively with three females.

increase of these insects is of no value. The same is probably true of other attractions, as molasses, and vinegar or beer, etc.

Deep plowing.—This was recommended as preventive of a second attack.

To prevent injuries to cultivated crops.—In most cases the easiest preventive is to surround these crops that are near the grass with a strip one or two rods wide of some crop upon which the larvæ cannot feed, as potatoes. There may be instances where a species has become firmly established in a cultivated field, because the same crop has been grown for a series of years. A change to some other crop upon which the larvæ cannot feed would probably rid the field of them.

METHODS OF STUDY.—The study of this genus was begun by the writer in July, 1892. Throughout the remainder of that season and during the season of 1893, continuous collecting supplied the material studied. The first care was to secure fresh unrubbed females which were heavy with eggs. These females were placed in tightly corked homeopathic vials with a few blades of green grass. Under these conditions they would live a week or more and lay freely. Besides those in the vials a number of females were usually placed in a breeding cage and observations were made upon each lot. The most convenient breeding cage was made by placing a lamp chimney over grass growing in a small flower pot; the top of the lamp chimney was covered with muslin. The pot was placed in a larger one and packed with sphagnum moss to prevent undue drying. In such a cage very nearly natural conditions were secured. The eggs in the vials were subject to daily observations and when they hatched the larvæ were described, some preserved in alcohol, and the rest placed in a cage. During the larval existence frequent observations were taken and full notes were made at the time of observation; whenever practicable, drawings were made. During the winter of 1892-93, all the larvæ died from some unknown cause. On this account it has been impossible to complete the round of life of the species studied.

In 1889, the Entomological Division of the Experiment Station ran six trap-lanterns throughout the season, and during the season of 1892 one. From the material taken in these trap-lanterns the periods of flight have been worked out and the number of

each sex taken determined. In the determination of species I found the male genital organs to be of great value. Many individuals after being in the trap-lantern could not be recognized by the markings. After a little experience it was only a few minutes' work to expose the genitalia of a softened individual. These organs, after the insect is softened, can be pushed into sight with a point of a pin and a glance is usually enough to determine the species.

VENATION OF THE WINGS.—The figures illustrating the venation of the wings are made from camera lucida drawings of bleached specimens. Great care was taken to represent accurately the outlines of the wings and the courses of the veins, but it was impracticable to use the same scale of enlargement for all; this has been done, however, on Plates XIII and XIV.

The nomenclature of wing veins adopted is that of Redtenbacher as modified by Professor Comstock in his essay on Evolution and Taxonomy. It seems unnecessary to describe the specific characteristics of the venation as these are shown in the plates better than I can describe them. Within the genus there are some specializations worthy of note. In the fore wing, vein III is five-branched except in *C. minimellus*, where it is but two-branched; vein VII is apparently four-branched in all the species except *C. minimellus*, where vein V_2 has coalesced with vein V_3 . In the hind wing the frenulum is a single stout spine in the male, while in the female it consists of two distinct spines except in *C. caliginosellus* and *C. hultsellus*, where it is divided at the tip only. The base of vein III is more or less rudimentary and a stump of vein V_{2+3} persists in some cases. Vein VII is apparently four-branched except in *C. minimellus*, where it is but three-branched.

STRUCTURE OF THE EXTERNAL REPRODUCTIVE ORGANS.—As no one writer, to my knowledge, has used a complete set of comprehensive terms for these important organs, it will be necessary to define the nomenclature used. In the male there are two pairs of lateral clasping organs, termed collectively, the *clasps* (Pl. V, Fig. 1, *v* and *h*). In this genus the outer pair appear to be more or less protective in function and are termed *valves* (Pl. V, Fig. 1, *v*). The inner pair are more or less chitinous and function as grappling hooks, the *harpes*. (Pl. V, Fig. 1, *h*.) Between the clasps is a more or less chitinous organ, the intromit-

tent organ or *penis*. (Pl. VII, Fig. 10, *pn.*) Dorsad of the penis and working vertically is a more or less beak-shaped organ, the *uncus*. (Pl. V, Fig. 1, *u.*) Articulated with the uncus and working vertically with it is a more slender Y-shaped organ, the *lower limb* of the uncus. (Pl. VIII, Fig. 16, *l.*) The penis extends between the branches and dorsad of the body of the lower limb of the uncus. The uncus and the lower limb function as vertical forceps, the clasps as lateral forceps. The uncus and the lower limb are articulated to an inverted keel-shaped organ, the *scaphium*. (Pl. V, Fig. 1, *s.*) The scaphium is composed of a pair of sclerites the *members* of the scaphium. (Pl. VIII, Fig. 14, *m, m.*) In some species the two members of the scaphium are loosely united. (Pl. XI, Fig. 26, *m, m.*); in other species the scaphium seems to be composed of a single sclerite. In the female the oviduct is guarded exteriorly by a pair of lateral plates, the *genital plates*. (Pl. V, Fig. 2, *g.*) The walls of the vagina are chitinous and in some species there are chitinous processes which are evidently correlated with the chitinous processes or hooks on the penis. (Pl. VII, Fig. 10, *pn.*) Later we will discuss the modifications of these organs in detail.

SYNOPSIS OF SPECIES.

Three tables are given. The first is purely artificial and is simply intended as an aid in the identification of the species. In the second the period of flight of the various species is presented in a condensed form. The third table is based largely upon a study of the exterior genital organs; in this table an effort is made to indicate the affinities of the species.

TABLE FOR THE SEPARATION OF SPECIES OF CRAMBUS.

- A. Fore wings some shade of gray, not yellowish.
 - B. Markings dark fuscous with brownish flecks, indistinct; size small; male antennae not pectinate. Pl. XIII., Fig. 2.
*2. caliginosellus.**
 - BB. Markings quite distinct, a distinct subterminal line.
 - C. Only a blackish spot on the tip of the discal cell; male antennae pectinate. Pl. XIII., Fig. 5. *5. mutabilis.**
 - CC. An oblique rather irregular discal stripe; size large; male antennae not pectinate. Pl. XIII., Fig. 3.
*3. interminellus.**

* The species marked with an * were taken at Ithaca.

- CCC. Large irregular blackish markings on and near tip of discal cell; size large; male antennae pectinate. Pl. XIII., Fig. 4. *4. hulstellus.*
- AA. The greater part of the fore wings yellow or of a brownish color.
 - B. Markings rather obscure, ground color yellow.
 - C. No subterminal line.
 - D. Fore wing an unbroken yellow. Pl. XIII., Fig. 1. *1. luteolellus.**
 - DD. Fore wing shaded with dark scales, black dots at tips of veins. Pl. XIII., Fig. 9. *9. vulgivagellus.**
 - CC. A more or less distinct subterminal line.
 - D. Fore wing a dark yellow. Pl. XIII., Fig. 7. *7. teterrellus.*
 - DD. Fore wings a light yellow.
 - E. Markings a light rufous, regular. Pl. XIII., Fig. 6. *6. decorellus.**
 - EE. Markings dark rufous, irregular. Pl. XIII., Fig. 8. *8. ruricolellus.**
- BB. Markings distinct.
 - C. A single broad white discal stripe.
 - D. Stripe not interrupted near the tip of the discal cell.
 - E. Stripe extending to the outer margin.
 - F. Stripe broad, scarcely narrowed beyond tip of discal cell and broadly expanded at outer margin. Pl. XIII., Fig. 10. *10. unistriatellus.**
 - FF. Stripe narrowed beyond discal cell and broadly expanded at outer margin. Pl. XIII., Fig. 12. *12. hastiferellus.**
 - FFF. Stripe almost interrupted, but extending by very narrow white line to the expanded tip at the outer margin; size small. Pl. XIV., Fig. 17. *17. extorralis.*
 - EE. Stripe not extending to the outer margin.
 - F. Tip of stripe simple. Pl. XIII., Fig. 11. *11. leachellus.**
 - FF. Tip of stripe bifid. Pl. XIII., Fig. 13. *13. praefectellus.*
 - DD. Stripe interrupted near tip of discal cell.
 - E. Fore wing broad, outer margin nearly straight, tip obtuse. Pl. XIV., Fig. 24. *24. alboclavellus.**

- EE. Fore wing narrow, outer margin strongly curved, tip acute.
- F. Stripe not branching near middle of discal cell. Pl. XIV., Fig. 25. *25. floridus.**
- FF. Stripe branching near middle of discal cell, the branch extending along vein VII, almost to the subterminal line. Pl. XIV., Fig. 27. *27. satrapellus.*
- CC. Two white stripes on the discal cell separated by a well defined rufous stripe of nearly equal width.
- D. Only black dots at the tips of the veins on the outer margin. Pl. XIV., Fig. 22. *22. agitatellus.**
- DD. Black dots and black lines extending from the dots along the veins almost to the subterminal line. Pl. XIV., Fig. 26. *26. laqueatellus.**
- CCC. No white discal stripe.
- D. A rather indistinct silvery discal stripe; size very small; apex of wing acute. Pl. XIV., Fig. 23. *23. minimellus.*
- DD. No discal stripe.
- E. Fore wing marked longitudinally with irregular dull black lines on a dull yellowish background. Pl. XIV., Fig. 19. *19. topiarius.**
- AAA. Ground color fore wings white.
- B. Fore wing nearly pure white. Pl. XIV., Fig. 18. *18. innotatellus.**
- BB. Fore wings not pure white.
- C. Markings black. Pl. XIV., Fig. 16. *16. turbatellus.**
- CC. Markings a rich brown. Pl. XIV., Fig. 15. *15. elegans.**
- CCC. Markings yellowish and black.
- D. A longitudinal yellow stripe. Pl. XIII., Fig. 14. *14. giradellus.**
- DD. No longitudinal yellow stripe, subterminal line bordered with light yellow. Pl. XIV., Fig. 20. *20. albellus.**

TIME OF FLIGHT OF SPECIES OF CRAMBUS AT ITHACA, N. Y.

	May.	June.	July.	August.	September.
<i>Crambus</i>					
<i>laqueatellus</i> Clem.....	*	* *			
<i>leachellus</i> Zinck.....		* *	* *		
<i>luteolellus</i> Clem.....		* *	* *		
<i>floridus</i> Zell.....		* *	* *		
<i>giradellus</i> Clem.....		* *	* *		
<i>albellus</i> Clem.....		* *	* *		
<i>interminellus</i> Walk.....		* *	* *		
<i>mutabilis</i> Clem.....		* *	* *	* *	*
<i>topiarius</i> Zell.....			* *		
<i>alboclavellus</i> Zell.....			* *	* *	
<i>caliginosellus</i> Clem.....			* *	* *	
<i>elegans</i> Clem.....			* *	* *	
<i>ruricolellus</i> Zell.....				* *	
<i>vulgivagellus</i> Clem.....				*	* *

Each * represents approximately two weeks.

SYNOPTICAL TABLE.

- A. Species that are grayish or dark colored. The free portion of the valve at least five times as long as broad. (*The Caliginosellus Division.*)
- B. Clasps nearly equal.
- C. No accessory spine ; clasps not anchylosed at the base.
Pl. V., Fig. 2. *caliginosellus.*
- CC. An accessory spine ; clasps anchylosed at base. Pl. V.,
Fig. 3. *interminellus.*
- BB. Clasps unequal.
- C. Harpe broadened. Pl. V., Fig. 4. *hulstellus.*
- CC. Harpe reduced to a stout spine. Pl. V., Fig. 5.
mutabilis.
- AA. Species that are yellowish or some shade of red. In the more specialized forms (in all described here except *C. luteolellus*) the free portion of the valve is less than five times as long as broad. (*The Luteolellus Division.*)
- B. Generalized representatives of the *luteolellus* division. The clasps are nearly equal and are at least five times as long as broad. Pl. V., Fig. 1. *luteolellus.*

- BB. Specialized representatives of the *luteolellus* division. The valves are less than five times as long as broad.
- C. Valve nearly triangular; harpe more or less reduced; accessory spine slender when present. (*Subdivision I.*)
- D. No accessory spine; general color yellow; harpe greatly reduced. (*The Decorellus Group.*)
- E. Harpe strongly recurved.
- F. Harpe rather long, irregular. Pl. VI., Fig. 6.
decorellus.
- FF. Harpe short, regular, bifid. Pl. VI., Fig. 7.
teterrellus.
- EE. Harpe not strongly recurved.
- F. Harpe short, tip acute. Pl. VI., Fig. 8.
ruricolellus.
- FF. Harpe shorter, tip obtuse. Pl. VI., Fig. 9.
vulgivagellus.
- DD. Accessory spine present.
- E. Uncus and lower limb nearly equal; color rufous with a broad white discal stripe. (*The Unistriatellus Group.*)
- F. Harpe long, strongly recurved at tip. Pl. VII., Fig. 10.
unistriatellus.
- G. Discal stripe near costa at base of wing, stripe extending to outer margin.* Pl. XIII., Fig. 12.
hastiferellus.
- GG. Stripe near center of discal cell, not extending to outer margin.
- H. Tip of stripe simple. Pl. XIII., Fig. 11.
leachellus.
- HH. Tip of stripe bifid. Pl. XIII., Fig. 13.
praefectellus.
- EE. Uncus greatly reduced in length. (*The Giradellus Group.*)
- F. Accessory spine at base of valve. Pl. VIII., Fig. 14.
giradellus.
- FF. Accessory spine near apical third of valve. Pl. X., Fig. 25.
floridus.

* I cannot separate these species on the male genitalia.

- CC. Valve not triangular; harpe elongate and with one or more spines near the tip. (*Subdivision II.*)
- D. An accessory spine near the tip of the harpe. Pl. VIII., Fig. 15. *elegans.*
- DD. Many short spines on the tip of the harpe. Pl. VIII., Fig. 16. *turbatellus.*
- DDD. A pair of spines on the tip of the harpe forming a crescent as seen from behind. Pl. VIII., Fig. 17. *extorralis.*
- CCC. Valves strongly flattened; harpe never elongate and narrow; accessory spine when present broad and plate-like or very short. (*Subdivision III. The Agitatellus Group.*)
- D. Harpe nearly as wide as valve.
- E. Harpe terminated by a retangular spine, edge smooth. Pl. X., Fig. 22. *agitatellus.*
- EE. Harpe terminated by a recurved spine, and with chitinous processes upon the edge. Pl. IX., Fig. 18. *innotatellus.*
- DD. Harpe much narrower than the valve at the base. Pl. X., Fig. 23. *minimellus.*
- DDD. Harpe reduced to a very short spine.
- E. A thick tuft of very long hairs near the harpe. Pl. IX., Fig. 19. *topiarius.*
- EE. No thick tuft of very long hairs near the harpe. Pl. IX., Fig. 20. *albellus.*
- DDDD. Harpe not a short spine.
- E. Uncus not strongly reduced, tips of valves oval.
- F. Harpe flattened, recurved. Pl. X., Fig. 24. *alboclavellus.*
- FF. Harpe flattened, concave, curved ventrad. Pl. XI., Fig. 26. *laqueatellus.*
- EE. Uncus greatly reduced, represented by two very thick tufts of curved hairs. Pl. XI., Fig. 27. *satrapellus.*

DESCRIPTION OF SPECIES.*

1. THE YELLOW CRAMBUS.

Crambus luteolellus.

PLATES I., V., XIII., FIG. 1.

This species may be recognized by its uniform yellow color and by its small size. This insect is confined to low wet lands. The moths fly about dusk during the latter part of June and July. Females were very hard to find and those taken laid but few eggs, which failed to hatch.

Egg.—A light rufous color when first laid. Form elliptical oval; size .42 by .3 mm. There are about fourteen prominent longitudinal ribs and numerous smaller transverse ridges.

2. THE SOOTY CRAMBUS.

Crambus caliginosellus.

PLATES I., V., XII., XIII., FIG. 2.

This species is a small dark colored moth with quite obscure markings. The adults fly in the early evening during the latter part of July and the first week of August. Very few of the moths are attracted to light. In the six trap-lanterns run through the season of 1889 only four males were taken, yet the species is quite common in Ithaca. Like the Yellow Crambus, this species is mostly confined to low wet lands. This insect appears to be more prolific than the Yellow Crambus; one female laid two hundred and seventy-five eggs in a vial, and this is probably below the average.† When first laid the eggs are a creamy white. They gradually turn to an orange rufous color, and hatch in from five to eight days.

* For a discussion of the more technical characteristics, and of those species the habits of which were not observed, see concluding part of this paper, treating of the Affinities of the Species.

† It is only occasionally that a female is taken in the field before she has laid any eggs. As a rule, I give the highest number of eggs I have observed any one female of a species to lay and then give the probable average based upon observations of other females of the same and other species. The numbers of eggs laid by a single female was determined by actual count and not by estimates.

The habits of the larvæ are thus described by M. H. Beck-with :* "This species does not penetrate the plant (corn) and remain feeding upon the tender inner parts, but works upon the outer portion just beneath the surface of the soil. Some plants were nearly girdled, and the worms were frequently found imbedded in cavities where they had fed upon the plants. In some instances as many as thirty worms were found in a single hill of corn. In many hills the plants had been entirely destroyed; in others they were small and had a yellow, sickly appearance. The greatest injury appeared to have been caused in that portion of the field adjoining a small strip of timothy sod that remained without plowing." In all probability this injury was caused by the moths flying into the field from the adjoining grass and dropping their eggs in the field. The eggs hatched and the larvæ had no other food, hence the injury to the corn.

Egg.—Creamy white when first laid, gradually turning to an orange rufous color before hatching. Form elliptical-oval with the ends slightly truncate; size .39 by .3 mm. The egg-shell has eighteen longitudinal ribs and numerous smaller transverse ridges. Pl. XII., Fig. 2.

Larva, first stage.—Head diameter .15 mm.; body diameter .125 mm.; length .875 mm. Color a smutty translucent white with irregular reddish spots on the middle line of the back; head a pale amber color. Scattered light colored hairs occur on the head and body. Five pairs of prolegs, occur on the seventh to tenth inclusive, and thirteenth segments.†

3. THE DRIED CRAMBUS.

Crambus interminellus.

PLATES I., V., XII., XIII., Fig. 3.

This insect is a rather large ashy gray moth with two irregular, oblique black markings upon the fore wing. This species seems to prefer low wet land. The moths fly mostly at or just after dark; they are attracted to light in large numbers but, as in most species, the majority taken are males.‡

* Bulletin No. XIV, Delaware Agricultural Experiment Station.

† This is true of all the species studied.

‡ H. Osborn records a predominance of females loaded with eggs. Insect Life, Vol. VI, No. 2, p. 72.

TRAP LANTERN RECORD. *C. interminellus*, 1889.

	June.																											July.														Aug.	Total.
	1	4	5	6	8	10	11	12	13	14	15	16	17	18	19	20	21	25	27	2	5	6	7	8	9	10	15	17	21	30													
Males . .	1	3	8	1	1	5	11	1	1	4	1	2	1	1	1	4	4	1		2	1	5	3	3	1	1		1	1	69													
Females .	3						1			1	5		3					1		1						2	1	1		19													

The period of flight extends through June and July; individuals have been taken as late as September 30. This long period of flight indicates great irregularity in time of breeding, but this does not necessarily imply more than one generation a year.

This species is quite prolific; one female laid one hundred and fifty eggs after capture and confinement in a vial. From observation of other species the average is probably between three and four hundred and one might expect to find individuals laying over five hundred eggs. When first laid the eggs are of a pale yellowish color; they gradually turn to an orange buff color and hatch in about eight days. The larvæ begin to feed soon after hatching. Their favorite position is in the axil of a leaf, where they eat the soft parenchyma. Even when but a few days old the larvæ eat most voraciously. When the larvæ are about a week old they begin to spin webs in the axils of the leaves; frequently several leaves are fastened together, in the midst of which the larvæ feed. When grass is not to be had the larvæ will feed upon sheep sorrel (*Rumex acetosella*).



FIG. 5.—Nest of larva. *C. interminellus*, enlarged.

About a month after hatching, the last of September, the larvæ begin to construct cylindrical perpendicular nests near the surface of the soil (Fig. 5). These nests are usually attached to one or more stalks of grass. The outside of the nest is covered with finely chewed bits of grass, while the inside is smoothly lined with silk. The nests are about a quarter of an inch long and about one-sixteenth of an inch in diameter. A little later the nests are strengthened by the addition of more grass to the outside. Occasionally a large piece of grass is woven into the side of the nest, but usually the pieces are small and of nearly equal size. As cold weather approaches, about November 1st, the larvæ

retire for the winter. The most of them close their nests with bits of grass before hibernating. Some of the nests have an underground chamber and passage way, which may allow the exit of the larvæ during mild days and also give access to the roots of the grass.

According to Dr. Lintner* the larvæ come forth in the spring, complete their growth, and pupate in June. The pupa state lasts about fifteen days. In this insect there seems to be no delayed pupation as has been recorded of the Vagabond Crambus. This species is very prolific and capable of causing considerable loss.

Egg.—A cream yellow color when first laid, gradually turning to an orange buff color before hatching. Form nearly elliptical; size .48 by .33 mm. The egg-shell has sixteen strong, longitudinal ridges and numerous smaller transverse ridges. Pl. XII., Fig. 3.

Larva, first stage.—Head diameter, .225 mm.; body diameter, .15 mm.; length, 1.2 mm. Head black, thoracic shield a dark brown; body a translucent white with numerous small black tubercles, each tubercle bearing one or more light colored hairs. Scattered light hairs occur upon the head.

When about half grown (late fall) the larva is 2 cm. long. The head and tubercles are black while the body is a mottled chocolate brown with a black stripe extending along the dorsal line.

Early in the spring the larva is about 3. cm. long. The head and thoracic shield are of a dark amber color; tubercles of the same color; there is a dull pinkish line along the middle line of the back; there are also irregular dark wavy subdorsal and lateral lines; body a pale straw color.

Pupa.—Thorax and head brown; abdomen rufous; spiracles dark brown; length about 2 cm.

Cocoon.—Oval, composed of a thick layer of bits of grass with particles of soil adhering to the outside. Inside, the cocoon is smooth and thinly lined with silk. The cocoon was made just below the surface.

5. THE DARK SPOTTED CRAMBUS.

Crambus mutabilis.

PLATES I., V., XIII., Fig. 5.

This species may be recognized by the dark spot near the middle of the slaty fore wing. There is also a dark subterminal line, which is usually rubbed so as to give the appearance of a second dark spot. This insect is larger than the Sooty Crambus and may be readily recognized by the pectinate antennæ of the

* First Report on Insects of New York, 1882, p. 149.

male. The moths fly in the latter part of the afternoon and in the early evening. The species is confined to low or damp land; they are also attracted to lights.

TRAP LANTERN RECORD. *C. mutabilis*, 1889.

	June.										July.										August.				Sep.	Total.	
	4	5	7	10	12	14	15	16	17	18	19	5	6	7	8	10	12	13	14	17	11	15	19	24	5		8
Males.	1	1	1	1	1	2	1	4	2	1	1	1	1	1	1	2	2	2	1	1	1	1	1	1	1	3	36
Females . .			1				1	2									1										5

This table shows that the adults fly through June, July, August, and into September. A similar record for 1892 is given by the single trap-lantern run that season. This is an exceptionally long breeding season. There may possibly be two generations in a year, but the weight of evidence seems against it.

The period of oviposition extends over a week or more. One female laid two hundred eggs the day after being taken, two hundred the next day, and one hundred the third day; at the end of a week she died, having laid seven hundred and twenty-five eggs after capture. Observation shows this is probably above the average. The eggs are a creamy white color when first laid but they soon change to a bright rufous color, and hatch in about ten days. All the moths laid a very large number of eggs, but the larvæ died soon after hatching; this seems to be the weak point in the life-history of this species.

Egg.—Creamy white when first laid, gradually turning to an orange rufous color before hatching. Form elliptical oval; size .51 by .36 mm. The egg-shell has sixteen longitudinal ridges and numerous small transverse ridges.

Larva, first stage.—Head diameter .18 mm.; body diameter .15 mm.; length 1.1 mm. Head pale yellowish with a sprinkling of sooty specks;* body a rather sooty semi-transparent white with irregular rufous blotches along the dorsum; scattered dark colored hairs occur on the head and the body.

* In descriptions of larvæ written in 1892 the head is black and the body considerably darker than given above, undoubtedly there is some variation.

7. THE BLUE GRASS WORM.

Crambus leterrellus.

PLATES I., VI., XII., Fig. 7.

This species has not been found in Ithaca, although it occurs in New York State. The moth may be recognized by its dark yellow color, the silvery subterminal line bordered by dark rufous, and by the black dots upon the outer margin at the tips of the veins. In Missouri this species is reported to outnumber all the other species of *Crambus*. The moths are most abundant about the first of August. The eggs are salmon color. The larvæ are a dingy white, and are found in galleries of fine white web in the grass. The web and the grass near by become sprinkled with the castings. In the dry weather of August and September larvæ were found on withered portions of a lawn, and they were evidently responsible to a considerable degree for the faded appearance and scanty growth of the blue grass during the latter part of the summer.

Miss Murtfeldt says:* "The growth of the larvæ was very slow and seemingly out of all proportion to the amount of web tubing constructed. A single larva, not more than one-third of an inch long, seemed to require for its domicile a gallery of 2 to 2½ inches in length and with a diameter two or three times its own. The upper part of this tube would be exceedingly diaphanous, but as it descended more and more of the frass was intermingled until at the base it became quite compact. During the day the larva rested quietly in this retreat, but at night it emerged and fed upon the freshest of the contiguous blades. So far as I could ascertain it seldom or never cut through the stalk or bored up or down through the heart of the plant.

The larvæ seemed to attain maturity from the middle to the last of September, after which they rested quietly for some time in their galleries, without inclosing themselves in more protective cocoons."

This apparent maturity was probably the cessation of active feeding, preparatory to hibernating. As the adults do not fly till

* Miss Murtfeldt, Bulletin No. 30, U. S. Department Agriculture, Entomological Division, p. 53.

August, it is probable that the larvæ hibernate when partially grown and complete their growth in the spring.

Later, in the jar containing specimens collected at various ages from the lawn, Miss Murtfeldt "found the remains of two or three hymenopterous parasites and four cocoons of the characteristic form, color and structure of *Meteorus*, closely resembling those of *M. hyphantriæ*."

Egg.—Obconical 0.5 mm. long, beautifully sculptured under the lens, with longitudinal ridges and finer cross lines, giving it a checkered appearance. Color, bright salmon pink.

Larva.—At first of a dingy cream white, minutely speckled with brown, with brown head.

At maturity 15 mm. in length, by 2 mm. in diameter, subcylindrical, slightly larger across thoracic segments. Color yellowish or greenish white, with dull green medio-dorsal stripe. The surface is much roughened with impressed lines, with conspicuous, raised corneous plates, from each of which rises a long, coarse, tapering yellow golden hair. Head with protruding lobes and rugose surface and of a dull whitish brown color. Cervical shield inconspicuous, darker than the head.

(These descriptions of the egg and larvæ are quoted from Miss Murtfeldt's account.)

8. THE RUSTIC CRAMBUS.

Crambus ruricolellus.

PLATES II., VI., XII., XIII., Fig. 8.

In 1892, this species was very abundant in Ithaca, N. Y., flying with, and to the casual observer, appearing the same as the Vagabond Crambus. The two species are very similar, especially when the specimens are somewhat rubbed. The Rustic Crambus has two irregular oblique rufous markings on the fore wing, while the Vagabond Crambus has no design upon the fore wings. This species is most abundant around damp places and near forests. The moths fly mostly on the early evening, though in dark or shady places they are quite abundant in the afternoon. At times they emerged in swarms, so one sweep of the net captured three or four individuals. The period of flight is limited mostly to the month of August. They are not attracted to lights in large numbers.

TRAP LANTERN RECORD. *C. ruricolellus*, 1889.

	August.						Septem-ber.	Totals.
	16	23	24	25	29	30	1	
Male	1	2	4	1	2	1	1	12
Female			3					3

As in most species, a large preponderance of males is here noticeable.

When first laid the eggs are creamy white in color ; they gradually turn to an orange buff color, and hatch in about twelve days. The young larva has a black head and a brick red body. For about ten days the larvæ appeared to eat very little; possibly they did not like young timothy (*Phleum pratensis*). After a time the grass was eaten with avidity ; clover was left untouched, while sheep sorrel (*Rumex acetosella*) was eaten. When not feeding the larvæ remained close to the stalks of grass or attempted to hide under the sheath. Where there is old growth the larvæ frequently bore through the stalks or leaves ; in these places they soon spin a web which conceals them more or less completely. When disturbed the larvæ coil into a helix if on a leaf ; if close to a good retreat they quickly disappear among the grass stalks. As cold weather comes on the larvæ feed more during the day. Late in the season, about the middle of October, the larvæ disappear from the leaves and the base of the stalks, and construct snug retreats just under the surface of the soil. The soil is pushed up into a crumbly mound under which the larva forms a silk-lined cavity. The entrance to these nests is usually by a tunnel or covered passage way about half an inch long. The nests are frequently constructed around the base of several stalks of grass, which the larvæ eat off at their leisure. These nests were made among young grass where there were no dead leaves, etc. In old sod similar nests are constructed, except that the outside of the nest is strengthened with bits of grass and other material. As the season advances the larvæ become darker colored till their bodies are almost a brownish black. On the approach of cold weather the larvæ feed less and less and finally retire for the winter ; at this time they average about one-fourth of an inch

long. The larvæ failed to survive the winter, and, as this insect is closely related to the Vagabond Crambus, the remainder of its life history is probably very similar.

Egg.—Creamy white when first laid, gradually turning to an orange buff color before hatching. Form elliptical oval; size .41 by .33 mm. The egg-shell has twenty longitudinal ridges and numerous smaller transverse ridges. Pl. XII., Fig. 8.

Larva, first stage.—Head diameter .225 mm.; body diameter .175 mm.; length 1.2 mm. Head nearly black; thoracic shield a dark reddish brown; body whitish translucent with many pale rufous spots on the dorsum of the fifth to the twelfth segments inclusive. Scattered dark colored hairs occur on the head and body.

Late in the fall the head and thoracic shield are almost black, the pale rufous spots have developed into dark brown tubercles, and the body has become deep brown.

9. THE VAGABOND CRAMBUS.

Crambus vulgivagellus.

PLATES II., VI., XII., XIII., Fig. 9.

This insect is a very ordinary appearing moth. The fore wings are a dull yellowish color flecked with black and with black dots on the outer margin at the tips of the veins. The labial palpi are very long and are flecked with black. The rest of the insect is of a more or less yellowish gray color. In spite of its commonplace appearance, this insect is very interesting economically.

The adults fly about dusk during the latter part of August and the first half of September.

TRAP LANTERN RECORD. *C. vulgivagellus*, 1889.

	August.										September.										Totals.	
	19	20	23	24	27	28	29	30	31	1	3	4	5	8	9	10	11	12	14	17		18
Males . .	2	2	12	6	3	4	2	14	2	5	6	1	7	9	3	1	3	3	1	1	1	88
Females .				3	1						1	1	3	8		4	1					22

The moths are attracted to light in large numbers, but mostly males are taken. In shady places the moths fly more or less during the day. This insect is very prolific; one female laid three

hundred and twenty eggs after capture; this is probably below the average number, as her abdomen was but moderately distended with eggs.

When first laid the eggs are a pale yellow color, but they gradually turn to a more or less deep rufous color, and hatch in from sixteen to thirty days, the time varying with conditions. While young the larvæ may usually be seen coiled up on a leaf in plain sight when not feeding; if disturbed, they remain quiet for a minute and then try to escape or they may drop at once by a thread of silk. As cold weather comes on the larvæ feed mostly during the day; occasionally they may be seen feeding in the early morning. When very young they eat only the soft parenchyma of the leaf, later the whole leaf is devoured. They feed mostly upon grass, though they will eat small grains. This species was bred in the hollow flower stalk of a species of wild parsley,* by H. G. Hubbard. The larvæ seemed to have fed mostly upon the soft pith. The pupæ were inclosed in a finely spun thin cocoon and frass was thickly strewn over the cocoon.

According to Dr. Lintner,† the larvæ commence feeding in the spring with the starting of the grass. They feed principally by night and remain in a cylindrical tube composed of silk and bits of grass, when not feeding.

Dr. Lintner says: "The depredations, when serious, are conspicuously noticeable when the larvæ are about three-fourths grown—about the middle of May.

When nearly mature the larvæ from some unknown cause, congregate in immense numbers on the trunks of trees near the ground.

When mature, about the 25th of May, they abandon their green cases, and build long cylindrical earthen cocoons, placed upright in the ground just beneath the surface.

The larvæ remain unchanged in the cocoons for two months or more, through June and July, when they transform to pupæ. The pupa state continues about two weeks."

Natural enemies.—Of the true parasites there are *Lampronata frigida* Cress., an Ichneumon Fly; *Cryptus mundus* Prov.;

* See label in Museum of Comparative Zoölogy, Cambridge, Mass.

† First Report on Insects of New York, 1882, p. 144.

Perilampus violaceous Dalm., a Chalcid; and also a species of *Tachina*, a fly.

Besides the true parasites a number of predaceous insects have been observed to prey upon this species of *Crambus*. Most prominent of these are a number of Carabid or Ground Beetles and several species of ants.

Egg.—A pale straw color when first laid, gradually turning to an ochraceous buff color before hatching. Form elliptical oval; size .45 mm. by 36 mm. The egg-shell has twenty longitudinal ridges and numerous smaller transverse ridges Pl. XII., Fig. 9.

Larva, first stage.—Head diameter .19 mm.; body diameter .175 mm.; length 1.25 mm. Head a dark brown; thoracic shield olive, and the body a straw yellow color. Scattered light colored hairs occur on the head and on the numerous small brownish tubercles on the body.

Larva, late in the fall.—2.5 mm. long. Head jet black; thoracic shield a deep brown; body brown with deep brown tubercles. The fifth to thirteenth segments inclusive are divided into cephalic and caudal portions by a short transverse constriction.

II. LEACH'S CRAMBUS.

Crambus leachellus.

PLATES II., VII., XII., XIII., Fig. II.

While not very abundant, this species has a wide distribution, having been taken in Illinois, Pennsylvania, Texas, New York, and Venezuela. It probably occurs in most of the United States and in corresponding latitudes in South America. The species is easily recognized by the silvery white stripe in the middle of the dull rufous fore wing; the stripe extends almost to the tip of the wing. The adults fly mostly in the late afternoon and during the early evening. They are attracted to light.

TRAP LANTERN RECORD. *C. leachellus*, 1889.

	June.					July.			Total.
	1	10	13	14	16	6	8	9	
Male			1	1	1	1	1	1	6
Female	1	1							2

The table and observations in the field show that this insect has

no sharply defined period of flight. A few individuals may be found almost any time in June or July.

The egg state of this species is of special interest because it exhibits some of the most marked changes in color. When first laid the eggs are a creamy white color; within twenty-four hours they change to a scarlet and the next twenty-four hours the color deepens to a geranium red. After the second day the eggs change but little in color. They hatch in about ten days. As the egg-shell is very thin the black head of the embryo shows through it

with great distinctness. Soon after hatching the

larvæ begin to feed most voraciously. Slight nests (Fig. 6) are spun on the blades of grass under which the larvæ retires when not feeding.

FIG. 6.—Nest of larva. *C. leachellus*.

Others spin a web in the axils of the leaves. In these nests frass is allowed to collect. As the larvæ become larger they build the more typical cylindrical nest at the base of the stalks of grass; these nests are strengthened on the outside with finely chewed bits of grass and they usually extend about half an inch below the surface. As the larvæ continue to grow the nests are built anew or enlarged and at this period the larvæ adopt the cut-worm habit and eat off blades of grass* and draw one end into the nest. Some of the nests contained finely chewed bits of green grass evenly packed around the inside of the nest. This material seemed to serve as reserve food.

About the first of August the larvæ construct a dense hibernaculum. The outside is thickly covered with bits of grass and particles of soil, while the inside is smoothly lined with silk. The rest of the life history is yet to be worked out.

* The writer observed a larva cut off a blade of grass and then pull the end down into its nest. The larva ate the blade nearly off and then pulled several times on a free corner but it was unable to tear the piece away; finally after repeated pulling and cutting at the base of the leaf, the larva succeeded in tearing loose the prize and fell with it to the ground, the blade lying upon the ground. The larva next dragged the base of the leaf to the mouth of its nest and then by repeated pulls upon a corner succeeded in bringing the blade to a perpendicular position and then in drawing the base of the blade down into the nest. The whole was carried on with almost human intelligence; the repeated cutting and pulling reminded me of a man alternately cutting and pulling at a tree.

Egg.—Creamy white in color when first laid, quickly changing to a scarlet and then to an intense geranium red; just before hatching the blackish head of the embryo shows through the thin shell very distinctly. Form nearly oval; size .51 mm. by .39 mm. The egg-shell is quite fragile and frequently collapses when the larva leaves it. There are twenty-two longitudinal ridges and numerous smaller transverse ridges. The circular markings around the micropyle are very characteristic. Pl. XII., Fig. 11.

Larva, first stage.—Head diameter .21 mm.; body diameter .18 mm.; length 1. mm. Head a brownish black, clypeus yellowish, antennæ nearly colorless, scattered hairs occur on the head; thoracic shield brown with a reddish tinge from the body contents; body a variable red, the color being the most intense in the thoracic region; there is a light stigmatal line; tubercles blackish and bearing dark hairs; prolegs almost rudimentary.

When about a month old the larvæ are 1.5 cm. long; the head is yellowish with irregular black markings; the body is brown with large blackish tubercles. When about six weeks old the larvæ are 3 cm. long and quite stout; the color has not changed.

14. THE YELLOW STRIPED CRAMBUS.

Crambus giradellus.

PLATES II., VIII., XIII., Fig. 14.

This moth is one of the largest Crambids. The adults may be recognized by the rather broad yellow stripe extending through the middle of a nearly pure white fore wing. This insect is confined to high land and is usually found in open fields. The moths fly in the afternoon and during the early evening. Light seems to have little attraction for them; in 1889 only four adults were taken in the trap-lanterns. The species is not very abundant, though widely distributed. The moths fly the latter part of June and more or less during July. Oviposition covers a period of from several days to a week; most of the eggs being laid during the first few days. Observation of other species shows that the average female probably lays about four hundred eggs; one female laid two hundred and twenty-five eggs in four days; she had doubtless laid some before being captured. The eggs hatch in about ten days. The larvæ feed upon grass and construct the typical Crambid nest. (Fig. 7).

Egg.—Creamy white when first laid, gradually changing to a bright orange color before hatching. Form elliptical oval; size .51 mm. by .33 mm. The egg-shell has seventeen longitudinal ridges and numerous smaller transverse ridges.

Larva, first stage.—Head diameter .24 mm.; body diameter .21 mm.; length 1.05 mm. Head and thoracic shield a glistening black; body a reddish straw color; scattered hairs occur on the head and body; the hairs on the body grow from minute tubercles which are concolorous with the body.

When about a month old the larvæ are 2. cm. long. The head is yellowish with irregular brown markings; the body is a slate color with brown tubercles.

15. THE PRETTY CRAMBUS.

Crambus elegans.

PLATES III., VIII., XII., XIV., Fig. 15.

This insect is a very pretty little moth. When the wings are folded it is readily recognized by the brown horse-shoe shaped mark upon the center of its back. The whole insect is marked in a rather irregular manner with brown on a white background. This species is not very abundant, yet by no means rare; it is quite generally distributed over the United States. It is found almost entirely upon high land and is frequently quite abundant near wet springy places. The moths fly mostly in the latter part of the afternoon and in the early evening. Though this insect is quite common in Ithaca, none were taken in the trap-lanterns. In Ithaca the adults fly during the most of July and the first half of August. They fly slower than most species and with a more irregular flight; their movement is so characteristic as to be easily recognized. The eggs hatch in from twelve to fourteen days.

Egg.—Creamy white when first laid, gradually turning to an orange buff color before hatching. Form oval; size .42 mm. by .30 mm. The egg-shell has sixteen longitudinal ridges and numerous smaller transverse ridges. Pl. XII., Fig. 15.

Larva, first stage.—Head diameter .2 mm.; body diameter .125 mm.; length 1.09 mm. Head and thoracic shield light brown; body a dirty straw color. Scattered hairs occur on the head and body.

18. THE UNMARKED CRAMBUS.

Crambus innotatellus.

PLATES III., IX., XII., XIV., Fig. 18.

This species is not very abundant around Ithaca, only one female being taken in 1892. None were taken in the trap-lanterns.

The few taken were captured in the early afternoon. This species has been taken in Maine, New Hampshire, and New York. The eggs hatch in about two weeks.

Egg.—Creamy white when first laid, gradually changing to a scarlet color before hatching. Form elliptical oval; size .45 mm. by .36 mm. The egg-shell has sixteen longitudinal ridges and numerous smaller transverse ridges. Pl. XII., Fig. 18.

Larva, first stage.—Head diameter .19 mm.; body diameter .15 mm.; length 1.05 mm. Body a dull straw color with irregular reddish blotches on the dorsum. Scattered light colored hairs occur on the head and body.

19. THE GARDEN CRAMBUS.

Crambus topiarius.

PLATES III., IX., XII., XIV., Fig. 19.

This species may be recognized by its small size and its linear markings of yellow and silver gray combined with short black lines and dots. This insect flies in large numbers with the White Crambus; the period of flight is practically limited to the month of July.

TRAP LANTERN RECORD. *C. topiarius*, 1889.

	July.													Totals.
	5	7	8	9	10	12	13	14	15	17	18	26	28	
Males ...	2	11	7	7	1	1	7	4	1	1	7	1	1	51
Females		3						3		1	1			8

This species flies most of the afternoon, and considerably after dusk as indicated by the trap-lantern record. This insect occurs on both high and low land, though not common in wet places. It is one of the most common Crambids in New York.

The species is very prolific; one female laid seven hundred eggs, three hundred being laid the first day. This is undoubtedly above the average. The eggs hatch in about ten days. The young larvae are very active and strong; they soon begin to con-

struct the typical cylindrical nest (Fig. 7), composed of web and an outer layer of bits of dry grass. The bits of grass are cut with great regularity, being about 2 mm. by 75 mm. In these nests the larvae retire when not feeding. The larvae feed upon the common grasses. Some were observed to eat considerable sheep sorrel (*Rumex acetosella*). The larvae feed mostly at night and occasionally a blade of grass was cut off and the end drawn into a nest. As cold weather came on the larvae became more dormant, the nests were made thicker, and finally in November the tops of the nests were closed. The winter is passed in the larva state. In the spring the larvae complete their growth and then transform, and emerge in July.

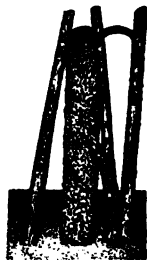


FIG. 7.—Nest of larva. *C. lo-piarius*, enlarged.

Egg.—Creamy white when first laid, gradually turning to a pinkish red color before hatching. Form elliptical oval; size .40 mm. by .30 mm. The egg shell has twenty longitudinal ridges and numerous small transverse ridges. Pl. XII., Fig. 19.

Larva, first stage.—Head diameter .2 mm.; body diameter .125 mm.; length .99 mm. General color a smutty white; head a little darker than the rest of the body. Scattered dark hairs occur on the head; numerous small dark colored tubercles occur on the body, each bearing at least one hair

20. THE WHITE CRAMBUS.

Crambus albellus.

PLATES III., IX., XII., XIV., Fig. 20.

This insect may be recognized by its white color with a few pale oblique markings, and by its small size. The adults fly the greater part of June and July. They fly mostly in the latter part of the afternoon and more or less during the whole of cloudy days. They rarely fly at twilight and therefore are not attracted to lights. During the two seasons trap lanterns were run by the Experiment Station only two males were taken. When found in the grass the moths rarely attempt to fly, but remain quiet till there is an opening, when they quickly glide out of sight among the dead grass. This insect is confined almost exclusively to high, rather dry land; they are most abundant in open fields.

The eggs hatch in about ten days. The young larvae soon construct cylindrical nests (Fig. 8), which are mostly above ground and are lined with silk, while the outside is strengthened with irregular bits of grass or particles of soil. The larvae remain in these retreats when not feeding, and frass is allowed to collect at the bottom of the nests. If a larva is removed from its nest it soon constructs another. Several larvae were observed to voluntarily forsake their nests and build elsewhere, which was probably due to the accumulation of frass in the old nest. The larvae feed mostly upon the common grasses. As cold weather advances the nests are built higher and more grass or other material is fastened to the outside of the nests. Finally, in November, just before retiring for the winter, the larvae close the tops of their nests with grass and a web, and hibernate in these retreats.



FIG. 8.—Nest of larva. *C. alboclavellus*, enlarged.

Egg.—Creamy white when first laid, gradually turning to a pale straw color before hatching. Form nearly oval; size .39 mm. by .33 mm. The egg-shell has eighteen longitudinal ridges and numerous smaller transverse ridges. Pl. XII., Fig. 20.

Larva, first stage.—Head diameter .175 mm.; body diameter .125 mm.; length .75 mm. General color a smutty white, head darker, and thoracic shield a little darker than the body. Scattered brown hairs occur on the head; rows of numerous small tubercles occur on the body. Fig. 4.

24. THE WHITE STRIPED CRAMBUS.

Crambus alboclavellus.

PLATES IV., X., XIV., Fig. 24.

This species is very common in Ithaca. The moths fly mostly the latter part of the afternoon and during cloudy days; they do not fly much after dark, as the trap-lantern record shows.

TRAP LANTERN RECORD. *C. alboclavellus*, 1889.

	July.					Total.
	4	17	18	22	24	
Males.....	1	2	2	2	2	9
Females			1			1

The moths fly mostly during July and the first half of August. This insect is one of the larger Crambids and is easily recognized by the broad white stripe near the edge of the wing. This stripe is broken by an oblique rufous line near the outer third of the wing; and the basal half of the stripe is divided longitudinally by a faint yellowish line. This species is quite prolific; one female has been known to lay five hundred and twenty-five eggs. The eggs hatch in about ten days.

The young larvae are strong and begin to feed at once. They soon construct nests of the typical form. (Fig. 7.) As the larvae grow older their straw colored bodies become darker till in September they are a mottled dark brown. Early in November the larvae close their nests and retire for the winter. In the spring the larvae complete their growth, pupate, and emerge as adults in July.

Egg.—Creamy white when first laid, gradually turning to an orange buff color before hatching. Form elliptical oval; size .42 mm. by .33 mm. There are about sixteen longitudinal ridges and numerous smaller transverse ridges.

Larva, first stage.—Head diameter .225 mm.; body diameter .14 mm.; length .625 mm. Head a deep brown, thoracic shield a lighter brown; body a straw color with a reddish mark along the middle of the back from the fourth to the ninth segments inclusive. Scattered light colored hairs occur on the head and body.

25. THE FLOWERY CRAMBUS.

Crambus floridus.

PLATES VI., X., XIV., Fig. 25.

This species resembles in a general way the White Striped Crambus, yet it is quite different in some respects. It may be recognized by the narrower white stripe along the costal edge of the narrower fore wing; the stripe is not broken near the tip nor is it divided longitudinally. The tip of the fore wing is also more pointed and the outer margin more strongly curved than in the White Striped Crambus. The moths fly the latter part of the afternoon and during the early evening.

TRAP-LANTERN RECORD. *C. floridus*, 1889.

	June.						July.				Totals.
	10	11	14	15	17	18	5	10	22	26	
Males.....	I	I	2	I	I	I	I	I		I	10
Females.....									I		I

The moths fly the greater part of June and July, though they are not abundant at any time. The insect is confined to high, rather dry land.

The species does not seem to be very prolific. The eggs hatch in about ten days. The young larvæ eat holes through the leaves or feed upon the edge of a leaf. In about two weeks the body becomes a dark mottled brown. At this time they establish themselves in the axil of a leaf or upon its flat surface; here they spin a slight web and soon construct a nest with an outer layer of bits of grass. The larvæ remain in these retreats when not feeding.

Egg.—Creamy white when first laid, gradually turning to a dark scarlet color before hatching. Form elliptical oval; size .39 mm. by .30 mm. The egg-shell has sixteen feeble longitudinal ridges and numerous smaller transverse ridges.

Larva, first stage.—Head diameter .21 mm.; body diameter .15 mm.; length 1.15 mm. Head black, labrum yellowish, scattered hairs occur on the head; thoracic shield a dark brown; body a straw color with fine reddish blotches giving it a pinkish cast. Scattered hairs grow from small dark tubercles.

When about two weeks old the body is a dark mottled brown. When a month old the larva is 1 cm. long.

26. THE PANELED CRAMBUS.

Crambus laqueatellus.

PLATES IV., XI., XII., XIII., Fig. 26.

This species was very abundant in Ithaca in 1893. It is one of our largest species. The moth may be recognized by the two white stripes extending the greater length of the fore wing and separated by a brown stripe of almost equal width. The ground color of the fore wing is brown. This insect is equally abundant

upon low as upon high ground, though the period of flight is longer on high ground. The moths fly more or less during the whole afternoon and during the early evening. During the early part of the afternoon mostly males are taken, while toward dark females are more abundant.

TRAP LANTERN RECORD. *C. laqueatellus*, 1889.

	May.			June.																Total.
	20	24	26	2	3	4	5	6	7	8	9	10	11	14	15	16	17	24		
Males.....	1	1	5	3	3		3	2		1		2		3	1	1			26	
Females.....	1					1			3		2	2	1	4	6	5	3	1	29	

This is the only species of *Crambus* where the number of females taken in a trap-lantern has exceeded the number of males. At first thought the trap-lantern would appear to be of use in checking the increase of this insect, but of all the females taken only one was heavy with eggs. The females seem to possess more vitality than those of other species. This insect is quite prolific; several of the females taken laid over two hundred eggs each, this is probably below the average.

The eggs hatch in about twelve days. The larvæ were quite active, but refused to feed upon timothy and therefore died.

Egg.—Creamy white when first laid, gradually turning to an orange color before hatching. Form subcylindrical; size .42 mm. by .30 mm. There are sixteen longitudinal ridges and numerous smaller transverse ridges. Pl. XII., Fig. 26.

Larva, first stage.—Head diameter .18 mm.; body diameter .15 mm.; length 1.15 mm. Head brownish black with whitish hairs; thoracic shield a light brown; body mottled with pale bright red and bearing blackish tubercles.

ON THE AFFINITIES OF SPECIES.

As might be expected of a large genus, *Crambus* includes several distinct lines of development. In attempting to trace the lines of specialization, the modifications of each organ should receive due consideration. We should go further than that and take into consideration the causes that have led to these modifications.

Before attempting to seek the cause of specialization, it may be well to ascertain just what has occurred within generic lines. In this study, based as it is on less than half of the North American species, one can hardly expect to find unbroken lines of development. We should expect to find gaps in the living forms and much larger ones when only a part of these are represented. Again, the larger the gaps, the greater the liability to error. In this study we shall assume that the better an organ is fitted to perform its functions the more highly specialized it is and, conversely, there may be a specialization by reduction as when an organ becomes useless and there is a reduction of the superfluous part.

The most striking and at the same time most superficial specific characteristics are the markings. As in many other groups of moths, we find that the most generalized species have a rather somber gray or yellow color with indistinct markings. The species studied may be divided into two very natural divisions on color alone. The grayish or dark colored species form a very natural division, the *Caliginosellus* Division. Later we shall see this division is united by strong structural affinities. The rest of the species are yellowish in color or of a color that may be derived from the yellow, and these represent an entirely different line of development, the *Luteolellus* Division. The lowest species of this division is *C. luteolellus*, which stands just below *C. caliginosellus* and is closely related to this species; the two probably having sprung from a common ancestor. This division may be divided into groups on color and no violence be done to structural affinities. The first group, the *Decorellus* Group, consists of yellowish moths with few or no markings. Next we might separate the *Unistriatellus* Group by the broad white stripe on a rufous fore wing. But as we attempt to classify the more specialized forms on maculation, we find the variation in color has increased more than structural variations and therefore our conclusions are at fault. In the more specialized forms the tendency to acquire adaptational colors has been greatly increased; consequently color may be a quite reliable systematic character in the more generalized species, but it is not in the more specialized forms.

In the venation there are considerable variations. These variations are useful in indicating the relative degree of specialization

of the different forms, but it is more in degree than in kind. In the antennæ there are some specializations and in two species this has been carried to a remarkable extent. In the labial palpi and the other mouth parts there are some modifications but they are of no great systematic value. The relative size of the species is of some value. The more generalized species seem to have a certain medium size from which the more specialized forms have varied each way. In the exterior genital organs there are great variations in form and these are of considerable value in tracing the phylogeny of the species. With the genitalia as the main witnesses and the other organs as subordinate witnesses, we will attempt to trace the affinities of the species. For the general plan of classification see the synoptical table.

1. The most generalized type is seen in *C. luteolellus*. Plates I., V., XIII., Fig. 1. The valve is elongate, oval in cross section and thickly covered with rather short hairs. The harpe is more chitinous and bears a dense row of rather short hairs. In the primitive *Crambus* the clasps were probably similar independent organs. In this species the uncus is longer than the lower limb, which is more slender. The scaphium is long and keel-shaped. From this simple type of genitalia there have been wide deviations along several lines. This species has the somber yellow color and the medium size of a generalized Crambid. The wings are rather broad and the veins branch nearer the base of the wings than in most species. The antennæ and palps exhibit little specialization. This insect is more closely related to the progenitors of the many species now living than any other form studied. Structurally, this insect is closely related to the *Caliginosellus* Division, but its color connects it with the lighter colored moths. As color in these more generalized species seems to be a quite reliable character, it may be allowed that *C. luteolellus* is not the progenitor of the *Caliginosellus* Division but that the separation occurred in a more primitive form. Therefore *C. luteolellus*, while being the most generalized species studied, is most closely related to the insect through which the more specialized forms have come.

The Caliginosellus Division.—Plates I., V., XII., XIII., Figures 2-5.

2. *Crambus caliginosellus*. Structurally this insect is most

closely related to *C. luteolellus* and can be separated only on the form of the scaphium, the form of the other organs being almost identical. Its dark color places it in this division and from this form the others are readily derived.

3. *Crambus interminellus*. This species is more specialized than the preceding as is shown by the narrower fore wing and by the larger size. The antennæ are somewhat specialized, the joints in the male becoming shorter and broader, while in the female a large seta has been developed on each joint; in both sexes the setæ upon the edge are shorter and finer than in the preceding species. The clasps retain the more primitive form but have become firmly anchylosed at the base, and an accessory spine has been developed. The genital plate is smooth and oval quite different from that of *C. caliginosellus*, showing that the species did not come directly from *C. caliginosellus* but in all probability from a more primitive form.

4. *Crambus hulstellus*. In this species the narrowing of the fore wing has been carried to a much greater extent and the veins branch much farther from the base of the wing. The female antennæ exhibit a degree of specialization while the male antennæ are highly specialized. The clasps depart somewhat from the primitive type and are not firmly anchylosed. This departure from the type seems correlated with a lightening in color and a greater distinctness in the markings. The uncus has become somewhat shortened and a distinct hook has been developed. The genital plate, though more specialized, shows a close relationship to *C. caliginosellus*.

5. *Crambus mutabilis*. Though the fore wings are broader than in the two preceding species, this insect is the most highly specialized of the division. The broadening of the wing, in this case, is a secondary development, and has followed as a consequence of the highly specialized male antennæ. When the antennæ became so efficient probably the wings became of secondary importance and consequently the process of narrowing stopped and a retrogression began. In due time the same thing will probably occur in *C. hulstellus*. The valve has retained its more primitive form, but the harpe has been reduced to a very efficient spine. Correlated with the efficiency of the harpe, a reduction of the uncus has taken place. The two members of the scaphium

have become sickle-shaped. The genital plate has nearly the rounded form of *C. interminellus* and this species is probably most closely related to that form.

The Luteolellus Division :

As before stated, *C. luteolellus* is placed in this division, but is treated of first, because it is the most generalized form of the species studied.

Subdivision I.

The Decorellus Group.—Plates I., II., VI., XII., XIII., Figures 6-9.

By their larger size and their uniform dull yellow color these species are seen to be more specialized forms than have descended from *C. luteolellus*, or allied species, and not from the dark colored *Caliginosellus* Group. In fact all the species of this division trace back to *C. luteolellus*.

6. *Crambus decorellus*. This species has a broad generalized wing. The antennæ are somewhat specialized, the joints being shorter and broader than in *C. luteolellus*. The valves are nearly triangular which is a marked departure from the primitive type. The harpe is greatly reduced and strongly curved. The uncus and the lower limb are well developed, probably because the harpe is so reduced and twisted as to be of little use. The scaphium is long and deep.

7. *Crambus teterrellus*. In this species the fore wing has been narrowed. The male antennæ are highly specialized. The valve has about the same form as in the preceding species, while the harpe has become more specialized by reduction in size and by the development of a double recurved hook. In consequence of the greater efficiency of the harpe the uncus has been greatly reduced. The genital plate has a slight tendency toward irregularity in outline.

8. *Crambus ruricolellus*. This species and *C. vulgivagellus* represent a line of development where the harpe has been greatly reduced and is therefore inefficient; the uncus has suffered but little reduction. The valves are more flattened than in the two preceding species. The wing is not so specialized as in *C. teterrellus*, but is more specialized than in *C. decorellus*. The labial palpi are longer proportionally than in *C. teterrellus* and shorter than

in *C. vulgivagellus*. The two members of the scaphium are short and nearly sickle-shaped. The genital plate is quite irregular.

9. *Crambus vulgivagellus*. The narrower wings and the greater development of the labial palpi indicate a higher degree of specialization than in the preceding. The antennæ are also more highly specialized. The harpe has been more reduced, but in other respects the genital organs are almost identical.

The Unistriatellus Group.—Plates II., VII., XII., XIII., Figures 10-13. The valve has nearly the same form as in *C. decorellus*, but it is more irregular. The harpe has become a stout recurved hook in *C. unistriatellus* but in the other species the harpe is more reduced. There has been developed at the base of the valve an accessory spine. This group was probably separated from a species closely allied to *C. decorellus*. In the *Decorellus* Group specialization has reduced the efficiency of the harpe and left the uncus comparatively unmodified. In this group the harpe and the accessory spine have become very efficient, while the uncus has become very slender. The uncus seems to be exactly alike in the four species of this group.

10. *Crambus unistriatellus*. This is the most generalized species of the group. In the fore wing none of the veins have become coalesced and the wing is broader than in the other species. The harpe in this group gives no reliable character for separating the species. In this species the harpe is strongly recurved and there are three recurved chitinous hooks on the penis. The genitalia show a high degree of specialization in some ways but the wings place this species as the most generalized.

11. *Crambus leachellus*. The fore wing is narrower than in the preceding and vein V_2 and vein V_3 have coalesced at the base; this has also occurred in the remaining species of this group.

12. *Crambus hastiferellus*. The narrowing of the fore wing and the coalescence of vein V_2 and vein V_3 has been carried still further. The genital plate is more specialized than in *C. leachellus*.

13. *Crambus præfectellus*. This is the most specialized of the group as is seen by the still narrower fore wings.

The Giradellus Group.—Plates II., IV., VIII., X., XIII., XIV., Figures 14 and 25.

14. The two species included in this group are highly specialized

forms. The venation of the species is almost exactly the same. In *C. floridus* the wing is a little narrower and the apex is more acute. The antennæ exhibit about an equal degree of specialization. In both species the valves are nearly triangular, while the harpe retains the elongate form. An accessory spine has been developed, and in *C. floridus* it is at the apical third, while in *C. giradellus* it is at the base of the valve. The species agree in the great reduction of the uncus. If the lower limb be taken as unity, the difference in length between the uncus and the lower limb will give the amount of the reduction. The reduction of the uncus seems to be correlated with the greater efficiency of the harpe or of the accessory spine. In *C. floridus* the uncus seems to be double; both lateral and ventral aspects are figured. The genital plates of the females show considerable similarity. *C. floridus* is the more specialized. The form of the valve and the accessory spine connects this group with the Unistriatellus Group.

Subdivision II.—Plates III., VIII., XII., XIV., Figures 15, 16, and 17.

This subdivision includes three highly specialized forms, which seem to be tips of as many lines of development. They agree in having the harpe highly specialized at or near the tip.

15. *Crambus elegans*. The fore wing is very broad. This generalized condition of the wings is correlated with highly specialized antennæ in both sexes. The tip of the valve is more or less oval. The harpe has coalesced at the base with the valve. There has been a shortening of the harpe and the accessory spine is strongly developed and near the tip of the harpe. Both the uncus and the lower limb seem to have suffered reduction. The form of the genitalia and of the joints of the antennæ seem to show a relation between this species and a form allied to *C. teterrellus*.

16. *Crambus turbatellus*. In this species the fore wing is quite generalized. The branches of the veins are all independent and arise rather near the base of the wing. The antennæ exhibit some degree of specialization. In the clasps there is a marked divergence. The valves have coalesced mesally and the harpes likewise; the harpes have also become anchylosed with the uncus and scaphium. Though the valves are twisted they have the

triangular form of *C. decorellus*. At the base of the valve there is a short flattened spine. The harpe has become highly specialized at the tip, there being on its mesal surface many short chitinous spines. The uncus has become reduced to a slender spine, while the lower limb has suffered little reduction.

17. *Crambus extorralis*. This species has no very close affinities among the species studied. The narrow fore wing indicates a high degree of specialization; all the veins branch near the outer margin of the wing. The antennæ are highly specialized. The primitive elongate form of the clasps connects this species with *C. luteolellus*. At the base of the valve a rudimentary spine occurs and this connects the species with the Unistriatellus Group. At the tip of the harpe a pair of curved spines have arisen. The uncus has been reduced somewhat, though not well shown in the figure. This species stands at what might be termed the head of a straight line of development.

Subdivision III. The Agitatehellus Group.—Plates III., IV., IX., X., XI., XII., XIV., Figures 18–27, except figure 25.

This group represents a line of development from forms in which the clasps became broadly and equally developed before other morphological changes occurred. This group includes the most specialized forms and, as might be expected, great diversity in form occurs in the genital organs.

18. *Crambus innotatellus*. In this species the fore wing is rather broad and the veins are independent. The antennæ are not highly specialized. The clasps are broad and nearly equal. Upon the edge of the harpe a row of chitinous processes has been developed, which terminates in a stout recurved hook. The uncus has been strongly reduced and modified. While the genitalia exhibit considerable specialization, it is what might be termed a sidewise development, and from the ancestors of this form, or a closely allied species, the next two species have arisen. The genital plate has been strongly modified.

19. *Crambus topiarius*. The broad fore wing and the independence of most of the veins stamp this species as more generalized than *C. albellus*. The male genitalia are similar. In each the harpe has been reduced very much. The valves are broad, flattened and convex mesally, but in *C. topiarius* a tuft of very long hairs has been developed at the base of the harpe. As a

consequence of the inefficiency of the harpe the uncus has remained comparatively unmodified and strong chitinous hooks have been developed on the penis. The hooks on the penis are undoubtedly correlated with chitinous processes in the vagina.

20. *Crambus albellus*. The wings are narrower than in the preceding species. Here the strongly reduced harpe is evidently correlated with the chitinous processes at the external orifice of the vagina. The valve, uncus, and lower limb are about the same as in *C. topiarius*. Chitinous processes on the penis would appear superfluous, as the harpe is made very efficient by the processes on the vagina, hence there is no such development as occurs in *C. topiarius*. The genital plate of the female is more specialized than in *C. topiarius*.

22. *Crambus agitatellus*. The venation of this species is almost the same as in *C. innotatellus*; the difference being no greater than might be expected within specific lines. The clasps are nearly equal and are not so specialized as in *C. innotatellus*. The same is true of the uncus and the genital plate. On the penis a stout recurved hook has been developed. The antennæ are more specialized than in *C. innotatellus*. These two species possess a nearly equal degree of development. This species is placed here because it leads most naturally to the following species and they are most closely related to the most specialized forms; it is really the most generalized species of this group.

23. *Crambus minimellus*. In this species the fore wings are most highly specialized. Radius is but two-branched in the fore wing, while media is but two branched in both fore and hind wings, vein V_2 having coalesced to the tip with V_3 . In this species the high degree of specialization exhibited by *C. extorralis* has been carried still further, but along a different line. The separation probably occurred below *C. agitatellus*. The clasps are simply modified from *C. agitatellus* and for this reason this species is placed in this group. Though the wing is the most specialized, it seems most natural to place the insect next to *C. agitatellus*, regarding the modifications of the wings as a sidewise development.

24. *Crambus alboclavellus*. The fore wing is almost the same as *C. agitatellus*, being only slightly narrower. The antennæ are a little more specialized, there being a large seta upon the side of

each joint. The tip of the valve has become more oval and the harpe has been reduced to a recurved flattened process. A short accessory spine occurs but it is very different from the accessory spine of the Unistriatellus Group. The uncus is very similar to that of *C. agitatellus* and like it has suffered little reduction. The genital plate is more specialized than in *C. agitatellus*.

25. *Crambus floridus*. See No. 14.

26. *Crambus laqueatellus*. This species is undoubtedly a more specialized form that has arisen from the progenitors of *C. agitatellus* or a closely allied form. The venation is almost identical, though the wing is a little narrower and exhibits a higher degree of specialization. The antennae are more specialized. The harpe has become shortened and strongly modified; both the spur of the harpe and the accessory spine are flattened concave processes, while a chitinous bar extends across the base of the valve. The uncus and the lower limb are well developed and closely resemble those of *C. agitatellus*. The members of the scaphium are loosely united and elongate. The genital plate is highly specialized and is similar to *C. agitatellus*.

27. *Crambus satrapellus*. This species has the narrowest fore wings and the apex is most prolonged. The veins are independent and branch near the margin. The antennae are not very highly specialized. The harpe is very efficient as is also the accessory spine. The form of these organs connect this species with *C. laqueatellus*. The uncus seems to have disappeared completely and a pair of very thick tufts of curved hairs has been developed. The other forms studied throw no light upon this singular modification. A study of other species will probably throw much light on this question.

Thus far the classification has been based entirely upon morphological studies. In no case has it been assumed that a species has descended directly from any species now living. The referring of species to each other was only to indicate relationship; the connecting links between the species have disappeared in all probability. Behind these great modifications of the genital organs there must be some plan, and if these forms have been rightly interpreted, we might expect to find some vital relations between closely allied species. In short, vital and morphological facts should harmonize.

A study of the adult moths shows little change except in the antennae, wings, and genitalia, but in neither antennae nor wings are there variations enough to lead us to regard them as the prime characters which separated any species. In the immature stages there is a great similarity among all the species studied. This similarity among the species in both adult and immature stages may be explained by the great similarity of habit. So far as is known the species of *Crambus* are grass insects. Throughout the growing season the grass offers practically the same conditions; hence great variation in the organs concerned in the function of nutrition could hardly be expected. The species are so small and require such a relatively small amount of food, that many individuals can exist upon a small area. The grass is so open and the moths fly so readily that there is little need of highly specialized organs to facilitate the finding of a mate; consequently in the secondary sexual organs we find a rather uniform degree of development.

In the male genitalia there are great variations. These variations may be explained by the almost uniform abundance of food throughout the growing season. If grass is kept cut or grazed rather close to the ground, as it frequently is in nature, it grows throughout the season. Under these conditions the insect that fed continuously throughout the growing season, and was not more destructive at one period than another, would succeed best in the struggle for existence. Like many larvæ, *Crambus* larvæ are more destructive just as they are completing their growth. A genus of insects might become adapted to these conditions by having several generations in a season or by breaking up into a number of species, each having a different breeding season. In *Crambus* there are a number of species in a locality breeding once a year, but at different times. Among the primitive Crambids the abundance of food at other than the usual period of larval existence would tend to preserve any variations in the time of breeding. Those individuals exhibiting the greatest variations in the time of breeding would naturally pair, and should any structural variations arise whereby pairing with individuals conforming more closely with the usual breeding time might be rendered difficult, such variations would be preserved by natural selection. A slight variation in the male genitalia might render

crossing difficult and in time lead to the separation of a species. The great variations in these important organs found in this genus lead us to this conclusion.

The record of species now living shows that variation in the time of breeding has most probably occurred in the genus, and is even now taking place. *C. laqueatellus* has a compact breeding season of about five weeks; *C. interminellus* has a breeding season extending through June and July and with a few individuals appearing the latter part of August, while *C. mutabilis* flies through June, July, August and into September. See Time of Flight of Species of *Crambus*. (Table p. 58.) This shows there is great variation in the length of the period of flight. If variation in time of flight is the first step in the separation of a species, we would expect closely allied species to have nearly the same period of flight. Secondly, we should expect that only the most specialized forms would fly earliest and latest. This is also borne out by the record. *C. laqueatellus*, *mutabilis*, and *C. vulgivagellus* are highly specialized forms and stand at the heads of different lines of development. The periods of flight of these species diverge most widely from the time when the more generalized forms fly. The closely allied species of these highly specialized forms have periods of flight which overlap the periods of their more specialized relatives.

That variation occurs in the genitalia is shown by members of the Unistriatellus Group. With the exception of *C. unistriatellus*, I have been unable to separate the species of this group by the character of the genitalia.

The genus *Crambus* has been adapted to its environment by a multiplication of species, which resemble each other in many respects, yet are well separated, as a rule, by variations in the male genitalia. A glance at the time of flight of the species shows that members of the various species fly throughout the growing season and that they are most destructive in June and July, the time when their food is most abundant.

BIBLIOGRAPHY AND RECORDED DISTRIBUTION OF
THE NORTH AMERICAN SPECIES OF THE GENUS
CRAMBUS.

Crambus agitatellus Clem.

Habitat. Mass., N. Y., Ill., Tex., London, Ont.

- 1860 Clemens. (Orig. Des.) Proc. Ass. Nat. Sci. Phil., p. 203.
1863 Zeller.* Mon. (p. 21); (*saltuellus*) ibid. p. 22.
1872 Zeller. Abhand. k.k. zool. bot. Gesellschaft. Vienna.
1874 Packard. Record Am. Ent.
1875 Zeller. Beiträge† p. 92.
1880 Grote. Can. Ent., XII., p. 77 (*saltuellus*); ibid. p. 77.
1887 Saunders. Can. Ent., XIX., p. 26.

Crambus albellus Clem.

Habitat. Me., Mass., N. Y., L. I., N. J., Penn., Can., Ont., Lab.

- 1860 Clemens. (Orig. Des.) Proc. Ass. Nat. Sci. Phil., p. 204.
1863 Zeller. Mon., p. 23.
1864 Packard. Proc. Ent. Soc. Phil., II., p. 418.
1880 Grote. Can. Ent., XII., p. 78.
1887 Saunders. Can. Ent., XIX., p. 26.

Crambus albilineellus Fern.

Habitat. South Cal.

- 1893 Fernald. (Orig. Des.) Can. Ent., XXV., p. 94.

Crambus alboclavellus Zell.

Habitat. Mass., N. Y., N. J., Va., O., Ill., Ky., Tex., Ont.

- 1863 Zeller. (Orig. Des.) Mon., p. 19.
1872 Zeller. Verh. z-b Wien., XII., 535-540.
1875 Zeller. Beiträge, p. 92.
1880 Grote. Can. Ent., XII., p. 77.
1886 Moffat. Can. Ent., XVIII., p. 31.
1887 Saunders. Can. Ent., XIX., p. 26.

Crambus anceps Grt.

Habitat. Cal.

- 1880 Grote (Orig. Des.) Can. Ent., XII., p. 18.; ibid. p. 78.

Crambus argillaceellus Pack.

Habitat. Lab.

* Chilo et Crambidarum genera et species; in Programm der Koeniglichen Realschule in Meseritz.

† Beiträge zur Kenntnis nordamerican Nachtfalter.

- 1868 Packard (Orig. Des.) Proc. Bos. Soc. Nat. Hist., II., p. 32.
Crambus attenuatus Grt.
 Habitat. Cal., Columb., Vanc. Is.
- 1880 Grote. (Orig. Des.) Can. Ent., XII, p. 18; *ibid* p. 78.
- 1881 Grote. Can. Ent., XIII., p. 67.
Crambus auratellus Clem.
 Habitat. Mass.
- 1860 Clemens. (Orig. Des.) Proc. Acad. Nat. Sci. Phil., p. 204.
Crambus bidens Zell.
 Habitat. Me, Mass., N. Y.
- 1872 Zeller. (Orig. Des.) Abhand. k.k. Zool. bot. Gesellschaft
 Vienna, Taf. III. fig. 17.
- 1874 Packard. Record Am. Ent.
- 1875 Zeller. Beiträge I, p. 89; *id.* Verh. z-b. Wien, XII.
- 1880 Grote. Can. Ent., XII., p. 77.
Crambus biothanatalis Hulst.
 Habitat. Cal.
- 1886 Hulst. (Orig. Des.) Trans. Am. Ent. Soc., XIII., p. 166.
- 1887 Fernald. (*behrensellus*) Ent. Am., III., p. 37.
Crambus bolterellus Fern.
 Habitat. Tex.
- 1887 Fernald (Orig. Des.) Ent. Am, III., p. 37.
Crambus caliginosellus Clem.
 Habitat. N. Y., Col., Hamilton, Ont.
- 1860 Clemens. (Orig. Des.) Proc. Ass. Nat. Sci. Phil., p. 203.
- 1880 Grote. Can. Ent., XII., p. 79.
- 1887 Saunders. Can. Ent., XIX., p. 88.
- 1891 Beckwith, H. M. Bull. Del. Coll. Agr. Expt. Stat. No.
 XIV., p. 13.
Crambus carpenterellus Pack.
 Habitat. Mountains of Cal.
- 1873 Packard. (Orig. Des.) Hayden's U. S. Surv., p. 548, fig. 1.
Crambus comptulatalis Hulst.
 Habitat. Vancouver's Island.
- 1886 Hulst. (Orig. Des.) Trans. Am. Ent. Soc, XIII., p. 167.
Crambus cuneolalis Hulst.
 Habitat. Tex.
- 1886 Hulst. (Orig. Des.) Trans Am. Ent. Soc, XIII., p. 166.
Crambus cypridalis Hulst.

Habitat. Utah.

- 1886 Hulst. (Orig. Des.) Trans. Am. Ent. Soc., XIII., p. 165.

Crambus decorellus Zinck.

Habitat. Mass., Md., Tex., Penn.

- 1819 Zincken. (Orig. Des.) Germ. Mag., IV., p. 250.

- 1863 Zeller (*polyactinellus*) Mon., p. 25.

- 1875 Packard. Record Am. Ent., p. 19.

- 1875 Zeller. Beiträge, I., p. 92.

- 1880 Grote. (*goodellianus*) Can. Ent., XII., p. 17 and 78.

- 1888 Fernald.=(*polyactinellus* Zell., *goodellianus* Gr., and *bon-
usculalis* Hulst.) Ent. Am., IV., p. 44.

Crambus delectalis Hulst.

Habitat. Arizona.

- 1886 Hulst. (Orig. Des.) Trans. Am. Ent. Soc., XIII., p. 165.

Crambus dissectus Grt.

Habitat. Me., N. Y.

- 1880 Grote. (Orig. Des.) Can. Ent., XII., p. 16; *ibid.*, p. 78.

- 1880 Grote. N. Am. Ent., I., p. 68, fig. 8., Pl. V.

- 1882 Grote. Papilio, II., p. 73.

Crambus dumetellus Hub.

Habitat. Cal.

- 1886 Hulst. (*trichusalis*) Trans. Am. Ent. Soc., XIII., p. 165.

Crambus edonis Grt.

Habitat. Kan.

- 1880 Grote. (Orig. Des.) Can. Ent., XII., p. 19; *ibid.*, p. 79.

- 1880 Grote. N. Am. Ent., I., p. 68, fig. 11, Pl. V.

Crambus elegans Clem.

Habitat. N. Y., N. J., Ill., L. I., O., Pa., Tex., Md., Hamil-
ton, Ont.

- 1860 Clemens. (Orig. Des.) Proc. Ass. Nat. Sci. Phil., p. 204.

- 1872 Zeller. (*terminellus*) Stett. Ent. Zeit., p. 473, Fig. 5, Pl.
II., id, Abhand. k. k. z-b. Gesellschaft, Vienna; id,=(*ter-
minellus*) Vehr. z-b. Wien., XXII., p. 535-540.

- 1874 Packard. Record Am. Ent.

- 1875 Zeller. Beiträge, p. 93.

- 1880 Grote. Can. Ent., XII., p. 78.

- 1886 Moffat, J. A. Can. Ent., XVIII., p. 31.

Crambus extorralis Hulst.

Habitat. Fla.

- 1886 Hulst. (Orig. Des.) Trans. Am. Ent. Soc., XIII., p. 165.
Crambus floridus Zell.

Habitat. Mass.

- 1875 Zeller. (Orig. Des.) Beiträge, I., p. 91; id. Verh. z-b
 Wien., XXII., p. 537.
 1880 Grote. Can. Ent., XII., p. 77.

Crambus gausapalis Hulst.

Habitat. Sier. Nev.

- 1886 Hulst (Orig. Des.) Trans. Am. Ent. Soc., XIII., p. 167.
Crambus giradellus Clem.

Habitat. N. H., N. Y., L. I., O., Pa., Md., London, Ont., St.
 Martin's Falls, Albany River, Hudson's Bay, N. Am.

- 1860 Clemens. (Orig. Des.) Proc. Ass. Nat. Sci. Phil., p. 204.
 1863 Walker. (*nivihumellus*) Brit. Mus. Cat., XXVII., p. 159.
 1863 Zeller. Mon., p. 19.
 1872 Lintner. Ent. Contributions, I., p. 184.
 1878 Lintner. Ent. Contributions, IV., p. 38.
 1880 Grote. Can. Ent., XII., p. 77.

Crambus hastiferellus Walk.

Habitat. Pa., Fla., La., Tex., Nova Scotia.

- 1863 Walker. (Orig. Des.) Brit. Mus. Cat., XXVII., p. 155.
 1877 Zeller. (*quinqueareatus*) Microlep., p. 38, Tf. I, fig. 16.
 1878 Butler. A. G. (*quinqueareatus*) Ill. Lep. Het., II., p. 40,
 fig. 16.

- 1880 Grote. (*quinqueareatus*) Can. Ent., XII., p. 77.

Crambus hulstellus Fern.

Habitat. Tex.

- 1885 Fernald. (Orig. Des.) Can. Ent., XVII., p. 56.

Crambus innotatellus Walk.

Habitat. Me., N. H., Mass., N. Y., O., Ill., Cal., Can., Ont.,
 Quebec, Nova Scotia, New Brunswick.

- 1863 Walker. (Orig. Des.) Brit. Mus. Cat., XXVII., p. 155.
 1863 Walker. (*inornatellus*) ibid, p. 157.
 1863 Zeller. (*sericinellus*) Mon., p. 49.
 1864 Clemens. (var. *inornatellus*) Proc. Ent. Soc. Phil., p. 418.
 1866 Walker. (*inornatellus*) Brit. Mus., Cat. XXXV.
 1880 Grote. (*sericinellus*) Can. Ent., XII., p. 77.
 1881 Grote. (*sericinellus*) Can. Ent., XIII., p. 66.

- 1881 Moffat, J. A. (*sericinellus*) Can. Ent., XVIII., p. 31.
Crambus interminellus Walk.
 Habitat. Me., N.H., Mass., N.Y., Ill., Neb., Vanc. Island, Can.,
 London, Ont., Nova Scotia.
- 1863 Walker. (Orig. Des.) Brit. Mus. Cat., XXVII.
- 1863 Zeller. (*exsiccatu*s) Mon., p. 37 and 38
- 1874 Zeller (*biliturellus*) Vehr. z-b. Wie 1., XXIV., p. 426.
- 1880 Grote. (*exsiccatu*s) Can. Ent., XII., p. 78.
- 1880 (*exsiccatu*s) 7th Ann. Rept. Surv. Adiron., Reg. N. Y.,
 p. 391.
- 1881 Lintner, *Alb. Even., Jour.* July 1; *Husbandman* (Elmira,
 N. Y.), Sept. 14; *Science* (N. Y. City) Oct., Vol. II, p. 467.
- 1881 Riley, C. V. *Am. Nat.*, Sept. p. 750.
- 1882 Lintner. (*exsiccatu*s) First Ann. Rept. Inj. Ins. N. Y., p.
 149-151.
- 1887 Osborn, H. Rept. Com. Agr., p. 154-160.
- 1887 Saunders, H. S. Can. Ent., XIX, p. 26.
- 1889 Gillette, C. P. Bull. No. 5, Iowa Agr. Exp. Sta., p.
 166-168.
- 1891 Bruner, L. Bull. Agr. Exp. Sta., Neb., p. 262.
- 1893 Osborn, H. Bull. U. S. Dept. Agr., Ent. Div., No. 30, p.
 44.
- 1893 Osborn, H. (*exsiccatu*s) *Insect Life*, Vol. VI, No. 2, p.
 72, 78.
- Crambus labradoriensis* Christ.
 Habitat. Lab.
- 1858 Christ. *Ent. Zeit.* XIX., 314; W. E. M., IV., 379.
- 1863 Walker. Brit. Mus. Cat. No. 27, p. 155.
- 1880 Grote. Can. Ent., XII., p. 77.
- Crambus laciniellus* Grt.
 Habitat. Me., U. S.
- 1880 Grote (Orig. Des.) Can. Ent., XII., p. 18: *ibid.* p. 78.
- Crambus laqueatellus* Clem.
 Habitat. Mass., N. Y., O., Ill., Ky., Tex., La.
- 1860 Clemens. (Orig. Des.) *Proc. Ass. Nat. Sci. Phil.*, p. 203.
- 1863 Walker. (*semifusellus*) Brit. Mus. Cat. No. 27, p. 159.
- 1863 Zeller. Mon., p. 24.
- 1872 Zeller. *Abhand. k. k. z-b. Gesellschaft.* Vienna.
- 1872 Lintner. *Ent. Contributions*, I, p. 184.

1873 Packard. Record of Am. Ent.

1875 Zeller. Beiträge., p. 91.

1880 Grote. Can. Ent., XII., p. 78.

Crambus leachellus Zinck.

Habitat. Me., Mass., N. Y., L. I., N. J., Pa., Ga., Ill., Cal., Tex., Vancouvers Island, Hamilton, Ont., Venezuela, Mendocino.

1818 Zincken. (Orig. Des.) Mag. der Ent., Dritter Band, p. 114.

1860 Clemens. Proc. Ass. Nat. Sci. Phil., p. 203.

1863 Zeller. (*pulchellus*) Mon., p. 18.

1872 Zeller. Abhand. k. k. z-b. Gesellschaft, Vienna; id (*pulchellus*).

1873 Packard. Rec. Am. Ent.

1875 Zeller. (*pulchellus*) Beiträge, p. 89.

1880 Grote. Can. Ent., XII., p. 16 and 77.

1887 Saunders. Can. Ent., XIX., p. 26.

Crambus luteolellus Clem.

Habitat. N. Y., Cal., London, Ont.

1860 Clemens. (Orig. Des.) Proc. Ass. Nat. Sci. Phil., p. 203.

1880 Grote (*duplicatus*) Can. Ent., XII., p. 79.

1887 Saunders. Can. Ent., XIX., p. 26.

1888 Cockerell (*uloe*) Ent. M. Mag., XXIV., p. 272.

1888 Fernald=(*uloe* Cock.) Ent. Am., IV., p. 44.

Crambus minimellus Rob.

Habitat. Pa., Tex.

1870 Robinson. (Orig. Des.) Ann. N.Y. Lyc. Nat. Hist., p. 315.

1880 Grote. Can. Ent., XII., p. 77.

1881 Grote. Can. Ent., XIII., p. 66.

Crambus multilineellus Fern.

Habitat. Fla.

1887 Fernald. (Orig. Des.) Ent. Am., III., p. 37.

Crambus mutabilis Clem.

Habitat. Mass., Conn., N. Y., O., Ill., Cal., Ky., Fla., La., Neb., Tex., Hamilton, Ont.

1860 Clemens. (Orig. Des.) Proc. Ass. Nat. Sci. Phil., p. 204.

1863 Zeller. (*fuscicostellus*) Mon., p. 44.

1880 Grote. (*fuscicostellus*) Can. Ent., XII., p. 79.

1885 Claypole, E W. (*fuscicostellus*) Can. Ent., XVII., p. 118.

1887 Saunders. (*fuscicostellus*) Can. Ent., XIX., p. 88.

1891 Bruner, L. (*fuscicostellus*) Neb. Bull. Agr., p. 262.

a. *hemiochrellus* Zell.

Habitat. Tex.

1877 Zeller. Ex. Microlep., 49.

1878 Butler. Ill. Lep. Het., II., p. 51.

1880 Grote. Can. Ent., XII., p. 79.

Crambus myellus Hbn.

Habitat. Me., Can., Nova Scotia.

1863 Walker. (*latiradiellus*) Brit. Mus. Cat., XXVII., p. 159.1877 Grote. (*interruptus*) Can. Ent. IX, p. 101.1880 Grote. (*interruptus*) Can. Ent. XII, p. 15 and 78.*Crambus occidentalis* Grt.

Habitat. San Francisco, Cal., Mendocino.

1880 Grote. (Orig. Des.) Can. Ent., XII., p. 16 and 77.

1881 Grote. Can. Ent., XIII., p. 66.

Crambus offectalis Hulst.

Habitat. Cal.

1886 Hulst. (Orig. Des.) Trans. Am. Ent. Soc., XIII., p. 166.

Crambus oregonius Grt.

1880 Grote. (Orig. Des.) Can. Ent., XII., p. 17 and 78.

1880 Grote. N. Am. Ent., p. 68, Fig. 9, Pl. V.

Crambus pectinifer Zell.

Habitat. Tex.

1877 Zeller. Exot. Microlep., p. 51, Pl. I, Fig. 20, a. b.

1878 Butler. Ill. Lep. Het., II., p. 53, Fig. 20, a. b.

1880 Grote. Can. Ent., XII., p. 79.

Crambus pexellus Zell.

Habitat. Tex., Col.

1863 Zeller. (Orig. Des.) Mon., p. 48.

1880 Grote. Can. Ent., XII., p. 79.

Crambus plejadellus Zinck.

Habitat. Mass., N. Y., Ga.

1821 Zincken. (Orig. Des.) Germ. Mag., IV., p. 251.

1863 Zeller. Mon., p. 26.

1880 Grote. Can. Ent., XII., p. 78.

1886 Hulst. (*bonusculalis*) Trans. Am., Ent. Soc. XIII., p. 167.1887 Fernald. (*bonusculalis* Hulst.) Ent. Am., III., p. 22.*Crambus præfectellus* Zinck.

Habitat. Mass., N. Y., N. J., Tex., Col., Can.

- 1821 Zincken. (Orig. Des.) Germ. Mag., IV., 249.
- 1860 Clemens. (*involutellus*) Proc. Ass. Nat. Sci. Phil., p. 203.
- 1863 Zeller. Mon., p. 18; (*pulchellus*) l. c.
- 1872 Zeller. Abhand. k. k. z-b. Gesellschaft, Vienna.
- 1875 Zeller. Beiträge, p. 89.
- 1878 Lintner. Ent. Contributions, IV., p. 38.
- 1880 Grote. Can. Ent., XII., p. 77.
Crambus repandus Grt.
 Habitat. Col.
- 1880 Grote. (Orig. Des.) Can. Ent. XII., p. 79.
Crambus ruricolellus Zell.
 Habitat. Me., N. H., N. Y., Pa., O., Ill., Can., London, Ont.
- 1863 Zeller. (Orig. Des.) Mon., p. 40.
- 1880 Grote. Can. Ent., XII., p. 79.
- 1887 Saunders. Can. Ent., XIX., p. 26.
Crambus satrapellus Zinck.
 Habitat. Fla., Ga.
- 1821 Zincken. (Orig. Des.) Germ. Mag., IV., p. 247.
- 1863 Walker. (*aculeilellus*) Brit. Mus. Cat., XXVII., p. 158;
 (*elegantellus*) l. c.
- 1863 Zeller. Mon., p. 16.
- 1870 Robinson. Ann. Lyc. Nat. Hist. N.Y., IX., p. 315 & 316.
- 1880 Grote. Can. Ent., XII., p. 77.
Crambus leterrellus Zinck.
 Habitat. N. Y. O., Pa., Va., N. C., Ga., Fla., Tex., Mo.
- 1821 Zincken. (Orig. Des.) Germ. Mag., IV., p. 251.
- 1860 Clemens. (*camurellus*) Proc. Ass. Nat. Sci. Phil., p. 203.
- 1863 Zeller. (*terrellus*) Mon., p. 27.
- 1874 Packard. Record Am. Ent., p. 19.
- 1880 Grote. Can. Ent., XII., p. 78.
- 1893 Murtfeldt, Mary E. Life hist.; eggs and larvæ described.
 Bull. U. S. Dept. Agr., Ent. Div., No. 30, p. 53.
Crambus topiarius Zell.
 Habitat. Me., Mass., Ill., N. C., Sierra Nev., Cal., Brit. Am.,
 St. John, New Brunswick.
- 1866 Zeller. (Orig. Des.) Stett. Ent. Zeit., 155, taf. 1, fig. 14.
- 1880 Grote. Can. Ent., XII., p. 17 and 78.
- 1882 Grote. Papilio, II., p. 74.

- 1886 Moffat. Can. Ent., XVIII., p. 31.
 1887 Saunders Can. Ent., XIX., p. 26.
Crambus trichostomus Christ.
 Habitat. Lab.
 1858 Christ. (Orig. Des.) Ent. Zeit., 313; W. E. M., 379.
 1880 Grote. Can. Ent., XII., p. 78.
Crambus turbatellus Walk.
 Habitat. Va., Pa., O., Ill., Can.
 1863 Walker. (Orig. Des.) Brit. Mus. Cat., No. 27.
 1863 Zeller. (*bipunctellus*) Mon., p. 23.
 1870 Robinson. (*bipunctellus*) Ann. Lyc. Nat. Hist. N. Y., IX.,
 p. 315.
 1880 Grote. (*bipunctellus*) Can. Ent., XII., p. 78.
Crambus undatus Grt.
 Habitat. Cal.
 1881 Grote. (Orig. Des.) Can. Ent., XIII., p. 66.
Crambus unistriatellus Pack.
 Habitat. Me., N. H., N. Y., Pa., Minn., Caribou Island, Cal., Lab.
 1863 Packard. (Orig. Des.) Proc. Bos. Soc. Nat. Hist., II., p. 54.
 Knaggs Ent. Mag., III., p. 54.
 1880 Grote. (*exesus*) Can. Ent., XII., p. 17 and 78.
 1880 Grote. (*exesus*) N. Am. Ent., I., p. 68, Pl. 5. fig. 7.
Crambus vulgivagellus Clem.
 Habitat. Me., Mass., N. Y., N. J., Pa., N. C., O., Ill., Tex.,
 Cal., Vancouver's Is., Hamilton, Ont., Nova Scotia.
 1860 Clemens. (Orig. Des.) Proc. Ass. Nat. Sci. Phil., p. 203.
 1863 Walker. (*aurifimbrialis*) Brit. Mus. Cat., No. 27, p. 157.
 1863 Zeller. (*chalybirostris*) Mon., p. 40.
 1872 Zeller. Beiträge.
 1874 Packard. (*chalybirostris*) Rec. Am. Ent., p. 19.
 1880 Grote. Can. Ent., XII., p. 17 and 79.
 1880 Grote. N. Am. Ent., I., p. 68, Pl. V., fig. 7.
 1881 Lintner. Alb. Even. Jour. May 23, July 1 and Sept. 8;
 Courier & Freeman (Potsdam, N. Y.) May 26; St. Lawrence
 Repub. June 8, Sept. 14 and 28; Husbandman (Elmira, N. Y.)
 Sept. 14; Ogdensburg (N. Y.) Daily Journ. Sept. 21; Count.
 Gent. (Albany, N. Y.) June 2, XLVI., p. 359; ibid. June 9;
 ibid. Sept. 29; Proc. Am. Ass., XXX., p. 267, 268; Rept.
 Ont. Ent. Soc., p. 12 and 13.

- 1881 Adams, J. Q., *Watertown* (N. Y.) *Daily Times* Aug. 22.
 1881 Riley, Am. Nat., XV., p. 574-576, 750, 914 and 915, 1008 and 1009.
 1881 Saunders, W. Can. Ent. XIII., p. 181-183, 199 and 200.
 1882 Saunders. Ann. Rept. Ent. Soc. Ont. '81-'82, p. 6, 13.
 1882 Riley. Ann. Rept. Com. Agr. '81-'82, p. 179-183
 1882 Lintner. Inj. Ins. N. Y., p. 127-149.
 1884 Cutting. 8th Rept. Ver. Bd. Agr., p. 276.
 1885 Fernald. Kingsley's Stand. Nat. Hist., II., p. 276.
 1886 Moffat. Can. Ent., XVII., p. 31.
 1891 Bruner, L. Neb. Bull. Agr., p. 261.
 1893 Bruner, L. Ann. Rept. Neb. State. Bd. Agr., p. 404.
 1893 Osborn, H. Insect Life, Vol. VI., No. 2., p. 72, 78.
Crambus zeellus Fern.
 Habitat. Me., Mass., N. Y., Pa., W. Va., Ill., Mo., Cal.
 1885 Fernald. (Orig. Des.) Can. Ent., XVII., p. 55.
 1885 Forbes. Ill. Crop. Rept., p. 38; id. Rept. Ill. St. Bd. Agr., p. 48; id. Ill. Rept. on Ins., p. 12.
 1886 Forbes. Can. Ent., XVII.; id. Miss. Essays on Economic Ent., p. 10.
 1886 Hulst. (*refotalis*) Trans. Am. Ent. Soc., XIII., p. 166.
 1887 Fernald. = (*refotalis* Hulst) Ent., Am., III., p. 22.

EXPLANATION OF PLATES.

The lettering is uniform throughout.

- | | |
|-------------------------------------|------------------------------------|
| Fig. 1. <i>C. luteolellus</i> . | Fig. 14. <i>C. giradellus</i> . |
| Fig. 2. <i>C. caliginosellus</i> . | Fig. 15. <i>C. elegans</i> . |
| Fig. 3. <i>C. interminellus</i> . | Fig. 16. <i>C. turbatellus</i> . |
| Fig. 4. <i>C. hulstellus</i> . | Fig. 17. <i>C. extorralis</i> . |
| Fig. 5. <i>C. mutabilis</i> . | Fig. 18. <i>C. innotatellus</i> . |
| Fig. 6. <i>C. decorellus</i> . | Fig. 19. <i>C. topiarius</i> . |
| Fig. 7. <i>C. teterrellus</i> . | Fig. 20. <i>C. albellus</i> . |
| Fig. 8. <i>C. ruricolellus</i> . | Fig. 22. <i>C. agitatellus</i> . |
| Fig. 9. <i>C. vulgivagellus</i> . | Fig. 23. <i>C. minimellus</i> . |
| Fig. 10. <i>C. unistriatellus</i> . | Fig. 24. <i>C. alboclavellus</i> . |
| Fig. 11. <i>C. leachellus</i> . | Fig. 25. <i>C. floridus</i> . |
| Fig. 12. <i>C. hastiferellus</i> . | Fig. 26. <i>C. laqueatellus</i> . |
| Fig. 13. <i>C. præfectorius</i> . | Fig. 27. <i>C. satrapellus</i> . |

The significance of the letters upon the anatomical plates are as follows: *a*, antennæ; *a. s.*, accessory spine; *c. p.*, chitinous process; *g*, genital plate (female); *h*, harpe; *l*, lower limb; *m. m.*, members of scaphium; *m. p.*, maxillary palpi; *p*, labial palpi; *pn.*, penis; *s*, scaphium; *v*, valve; *vg.*, vagina; *u*, uncus.

In Fig 16 the ventral aspect of the harpes and the dorsal aspect of the valves are represented; in figures 2, 10, 11, 12, 13 and 20 the mesal aspect of the right clasps are represented; in the others it is the mesal aspect of the left clasps.

PLATE I.

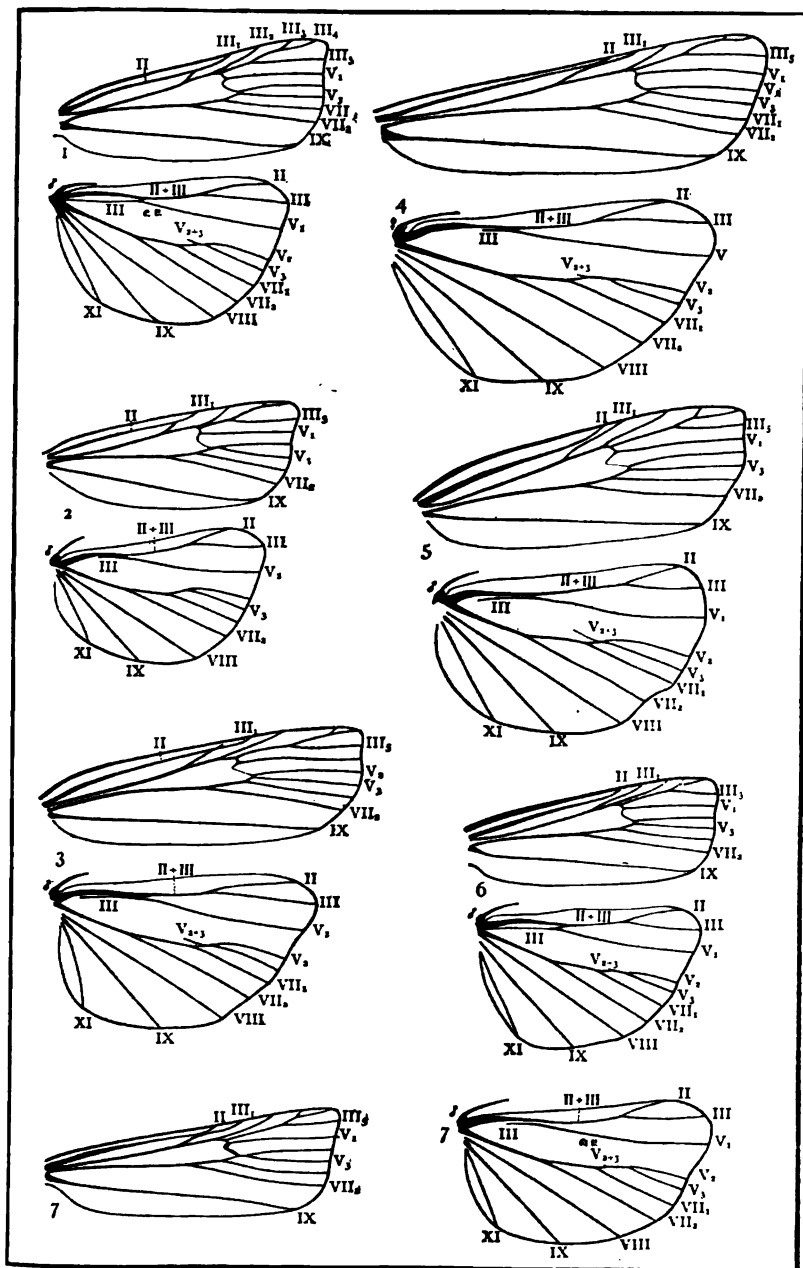


PLATE II.

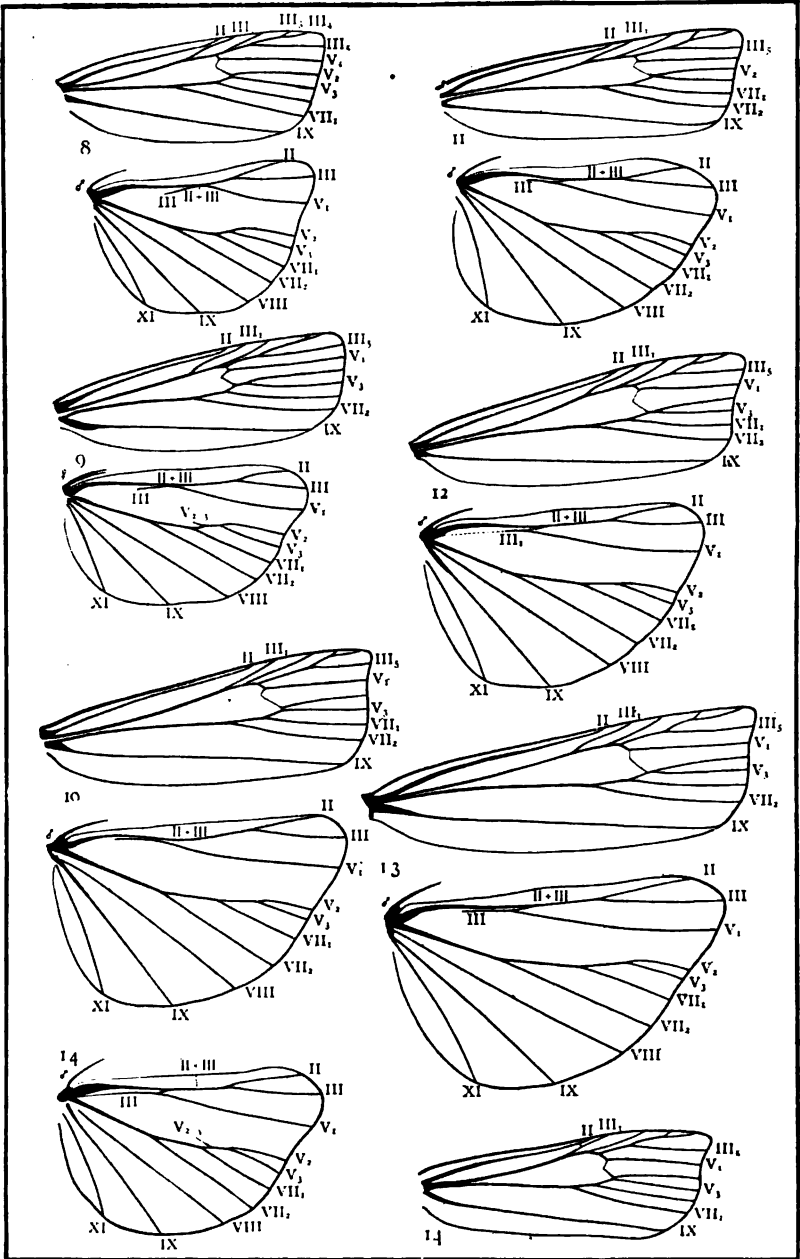


PLATE III.

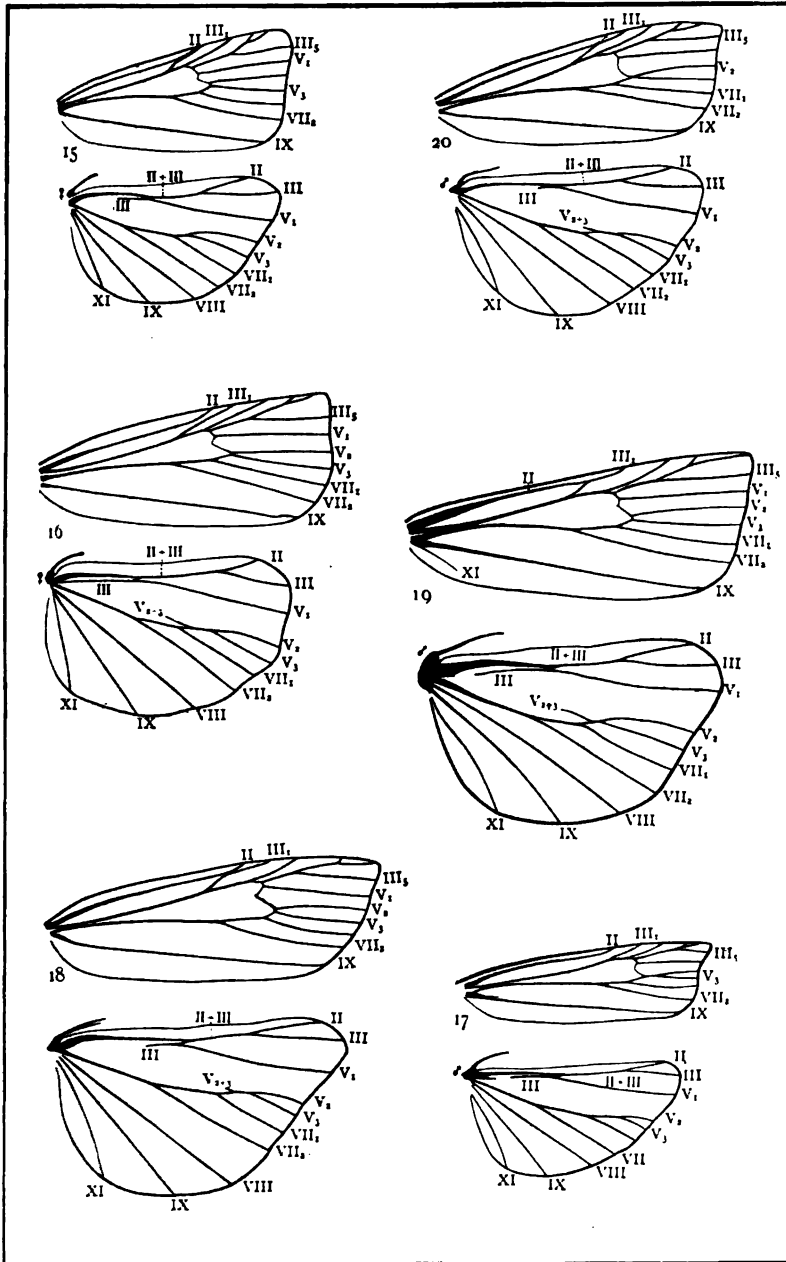


PLATE IV.

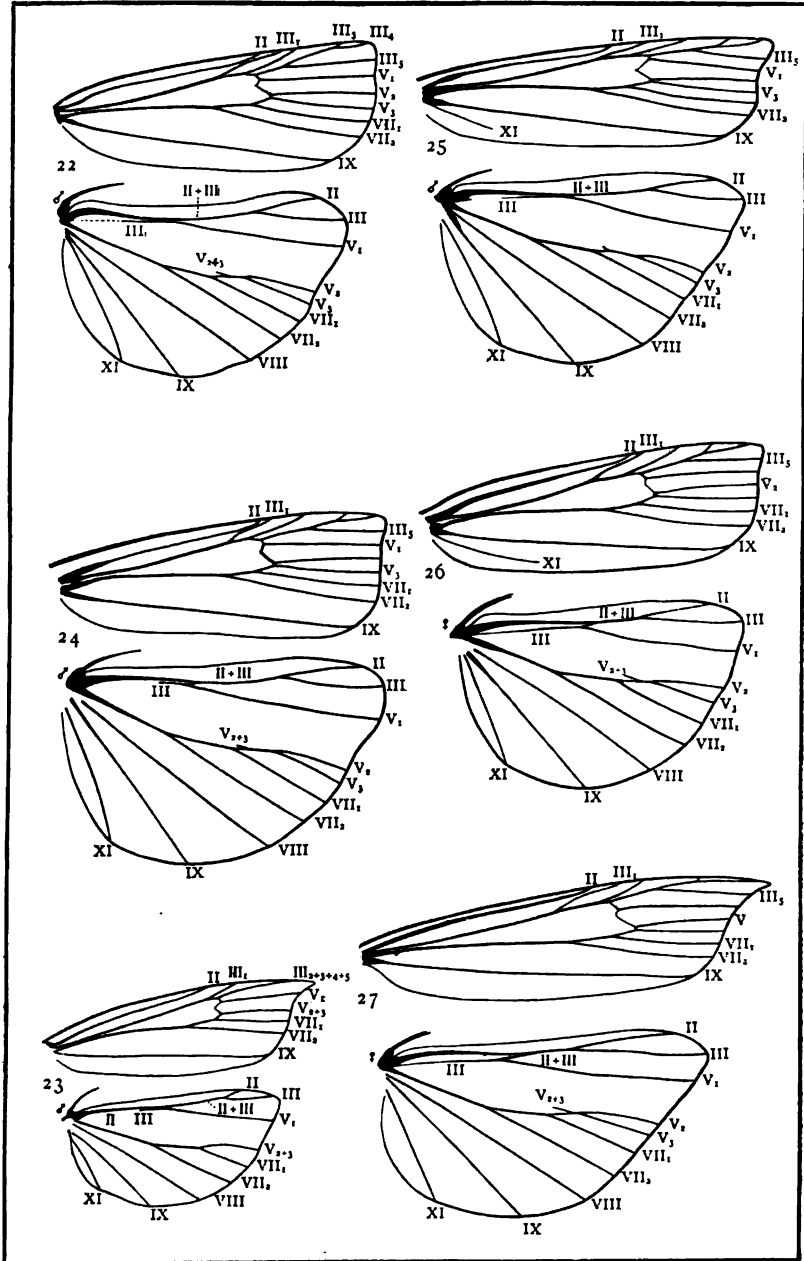


PLATE V.

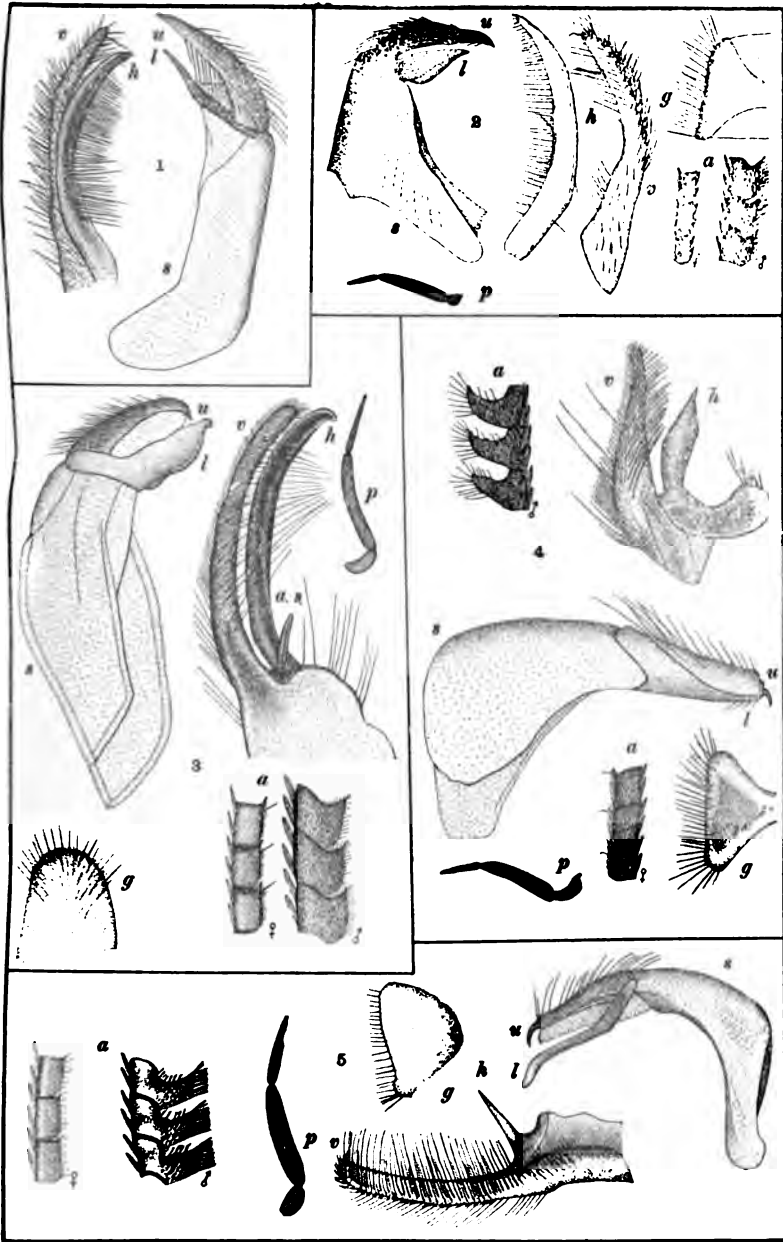


PLATE VI.

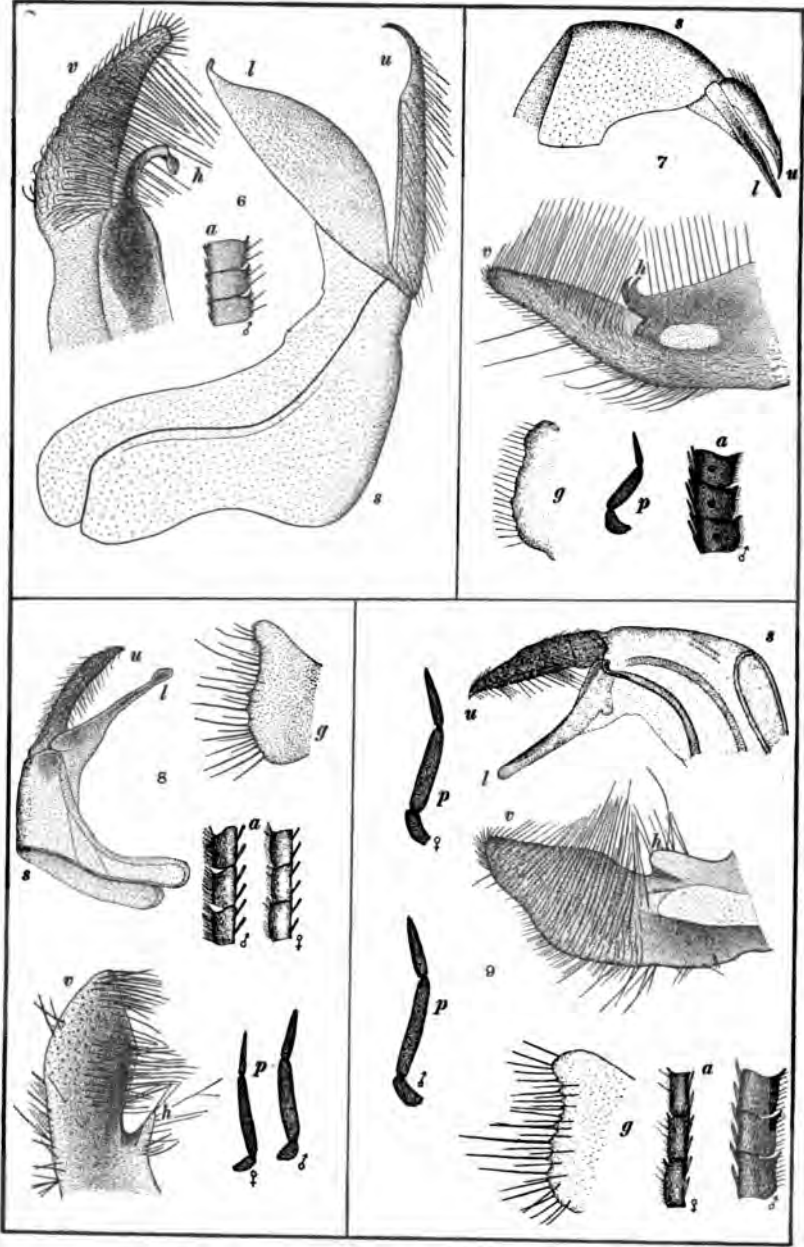


PLATE VII.

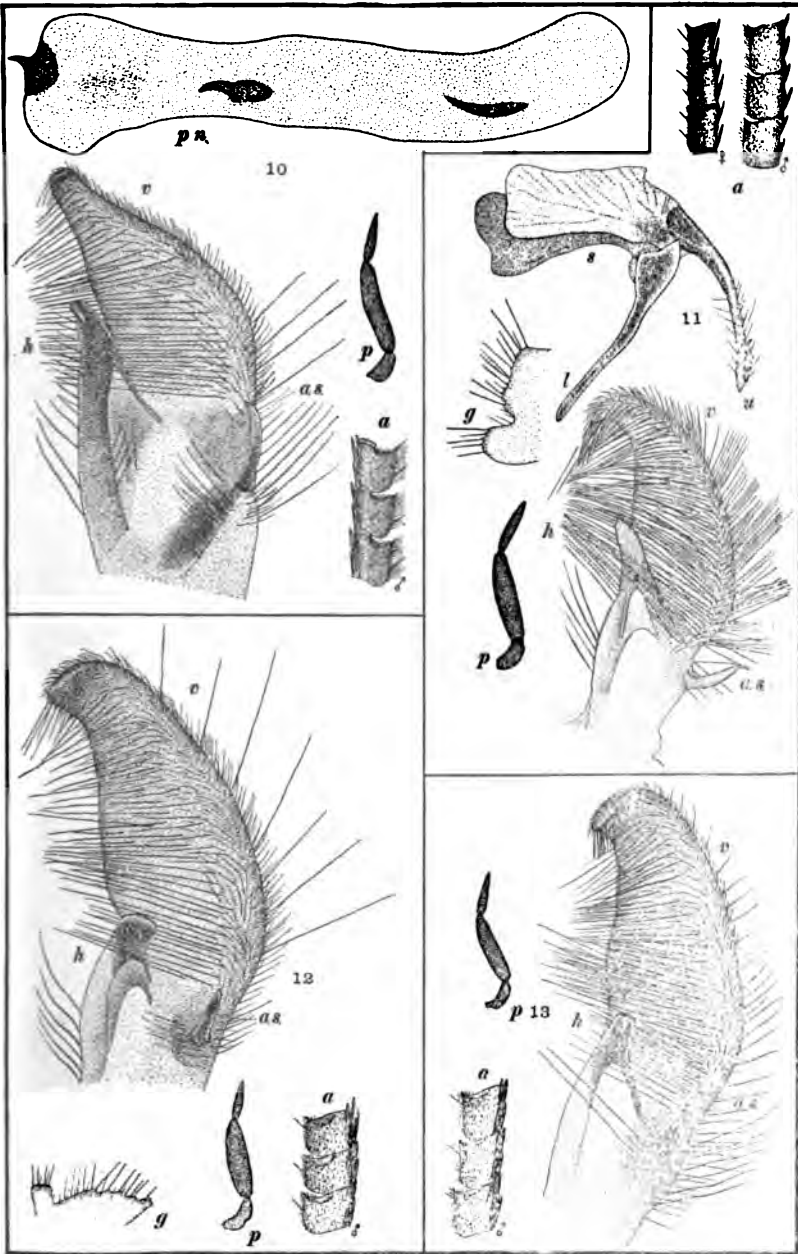


PLATE VIII.

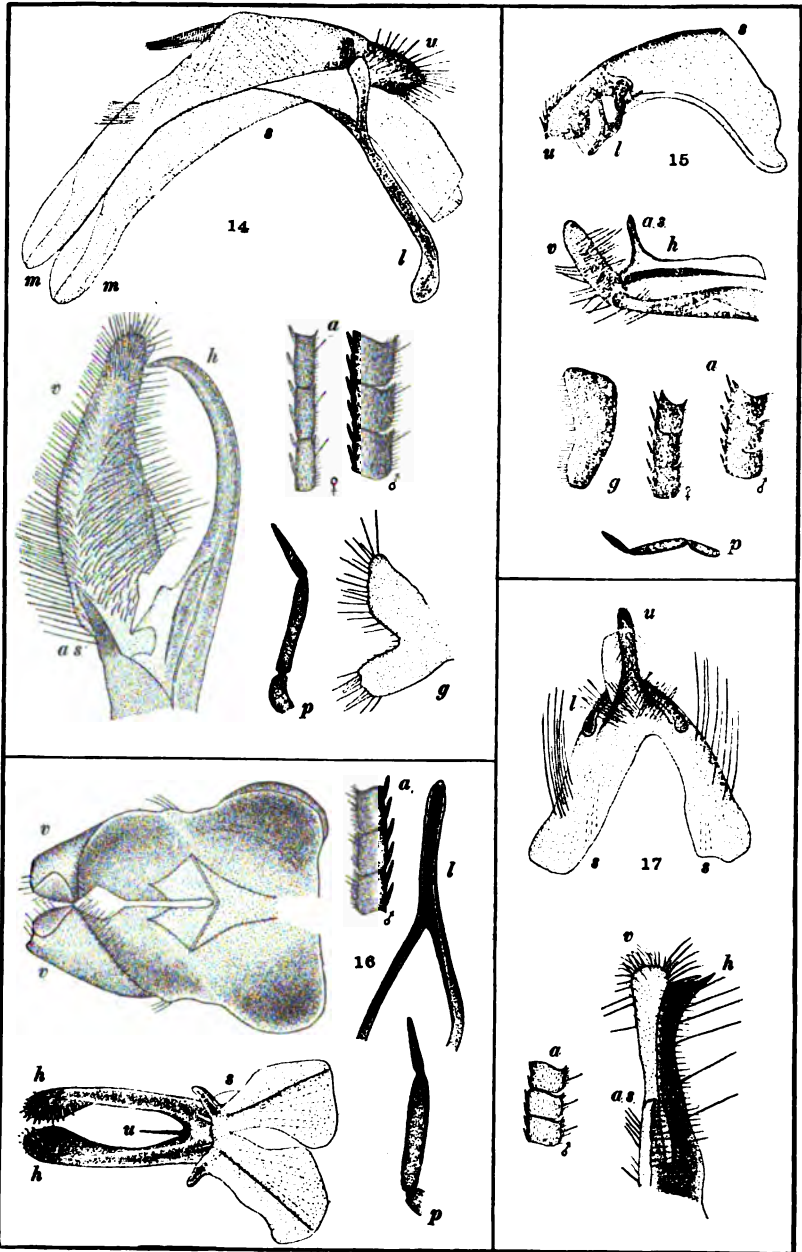


PLATE IX.

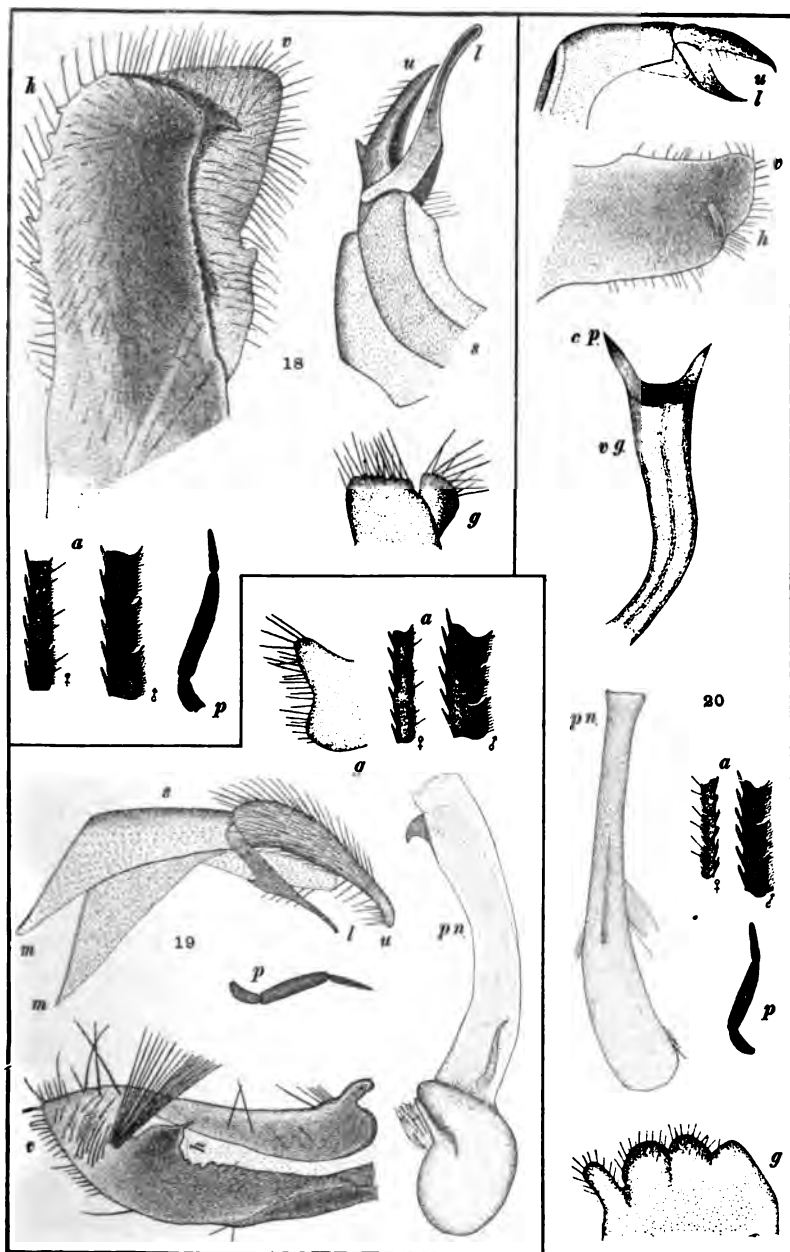


PLATE X.

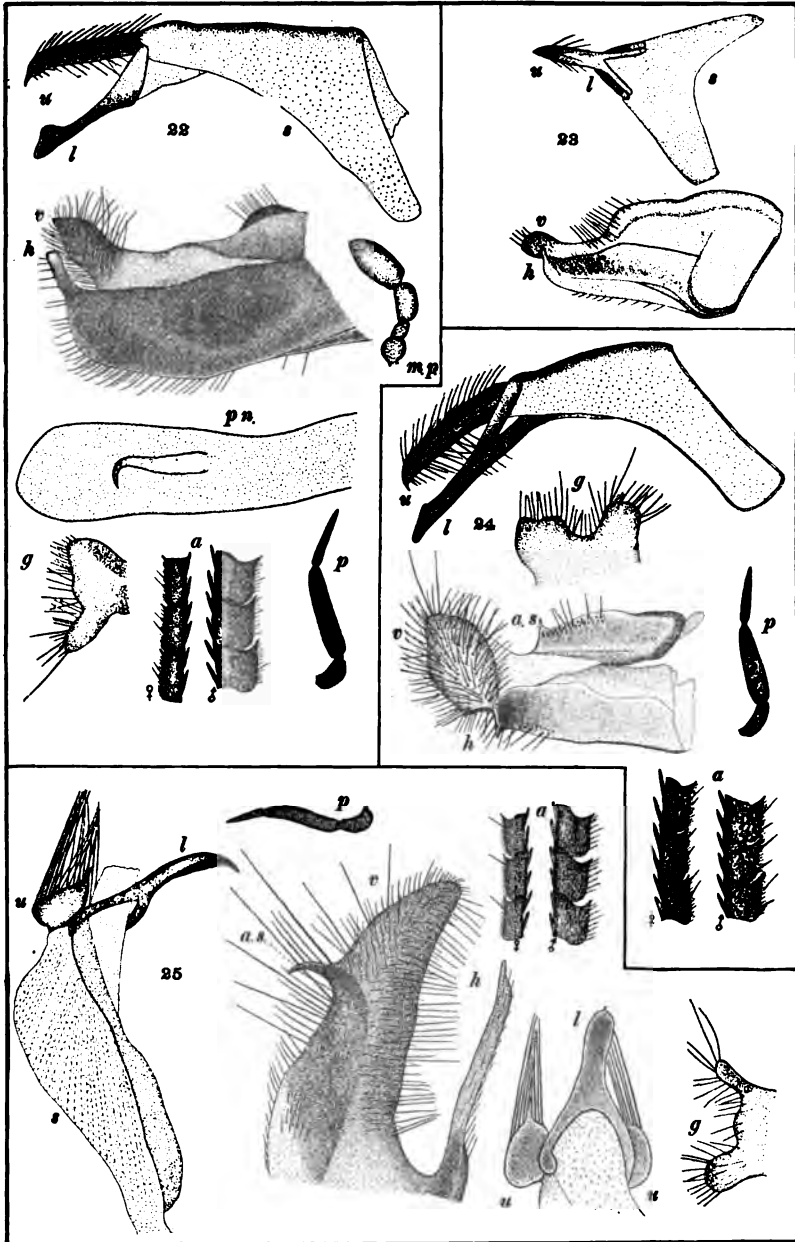


PLATE XI.

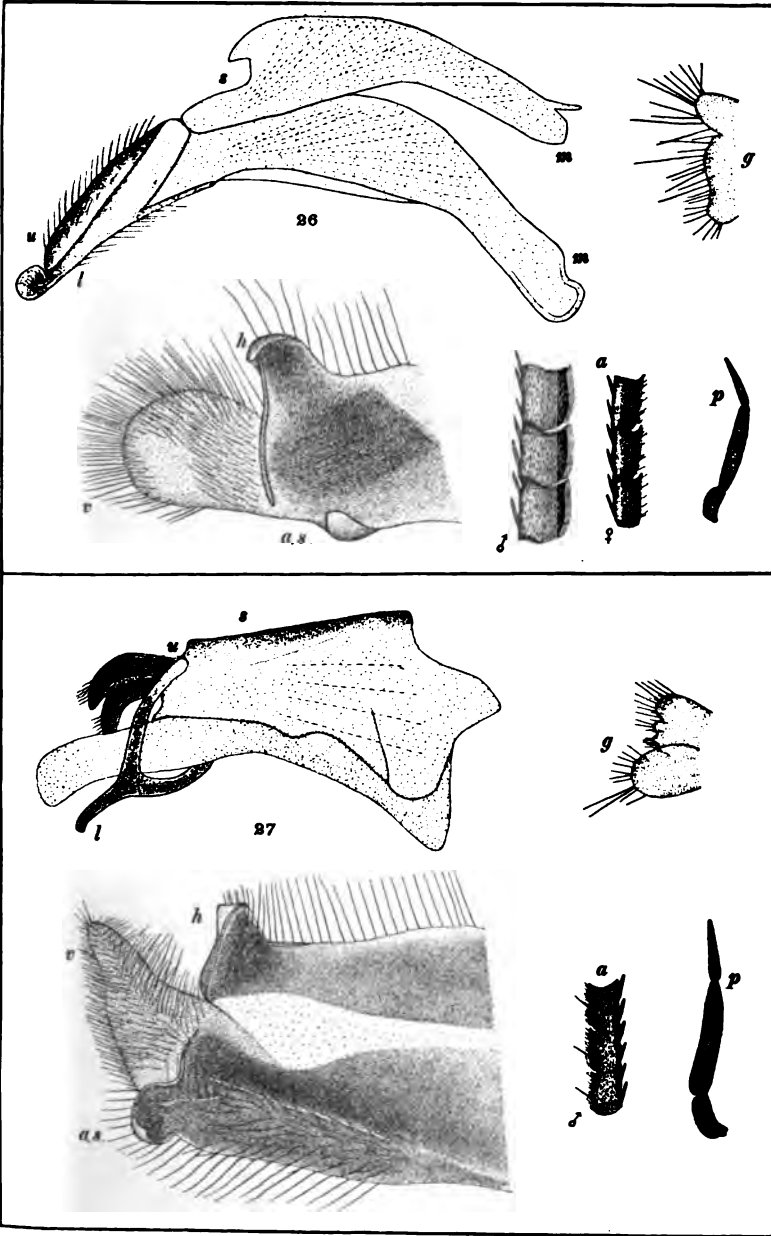


PLATE XII.



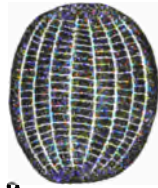
2



3



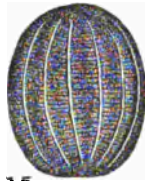
8



9



11



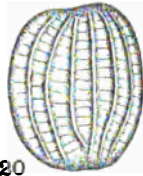
15



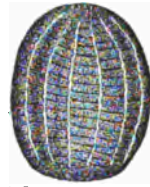
18



19



20



26



PLATE XIII.

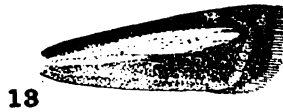
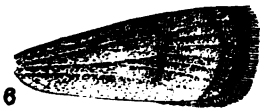
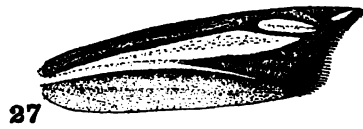
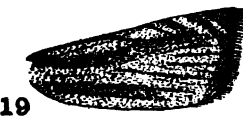
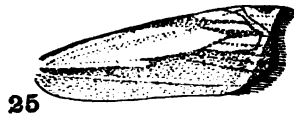
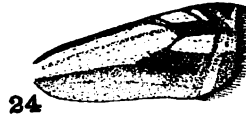
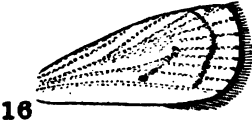
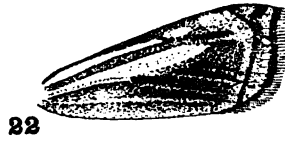


PLATE XIV.



3 0.679
M7
C886
UNIV. OF
JAN 18 1894

Bulletin 65.

April, 1894.

Cornell University Agricultural Experiment Station.

VETERINARY DIVISION.

TUBERCULOSIS

IN RELATION TO

Animal Industry and Public Health.

—BY—

JAMES LAW.

PUBLISHED BY THE UNIVERSITY,
ITHACA, N. Y.
1894.

ORGANIZATION.

BOARD OF CONTROL: THE TRUSTEES OF THE UNIVERSITY.

STATION COUNCIL.

President, JACOB GOULD SCHURMAN.

Hon. A. D. WHITE,	-	-	-	-	Trustee of the University.
HON. JOHN B. DUTCHER,	-	-	-	-	President State Agricultural Society.
I. P. ROBERTS,	-	-	-	-	Professor of Agriculture.
G. C. CALDWELL,	-	-	-	-	Professor of Chemistry.
JAMES LAW,	-	-	-	-	Professor of Veterinary Science.
A. N. PRENTISS,	-	-	-	-	Professor of Botany
J. H. COMSTOCK,	-	-	-	-	Professor of Entomology.
L. H. BAILEY,	-	-	-	-	Professor of Horticulture.
H. H. WING,	-	-	-	-	Asst. Professor of Dairy Husbandry.
G. F. ATKINSON,	-	-	-	-	Asst. Professor of Cryptogamic Botany

OFFICERS OF THE STATION.

I. P. ROBERTS,	-	-	-	-	Director.
HENRY H. WING,	-	-	-	-	Deputy Director and Secretary.
E. L. WILLIAMS,	-	-	-	-	Treasurer.

ASSISTANTS.

M. V. SLINGERLAND,	-	-	-	-	Entomology.
GEO. C. WATSON,	-	-	-	-	Agriculture.
G. W. CAVANAUGH,	-	-	-	-	Chemistry.
E. G. LODEMAN,	-	-	-	-	Horticulture.

Offices of the Director and Deputy Director, 20 Morrill Hall.

Those desiring this Bulletin sent to friends will please send us the names of the parties.

BULLETINS OF 1894.

62. The Japanese Plums in North America.
63. Co-operative Test of Sugar Beets.
64. On Certain Grass-Eating Insects.
65. Tuberculosis in Relation to Animal Industry and Public Health.

TUBERCULOSIS IN RELATION TO ANIMAL INDUSTRY AND PUBLIC HEALTH.

ITS PREVALENCE AND RELATIVE IMPORTANCE.

Tuberculosis is so extensively prevalent and proves such a veritable scourge throughout the civilized world that no disease is so deserving of close and accurate study, or of the enforcement of effective measures for its suppression. Cholera, yellow fever and small pox, which occasionally invade our territory, creating universal terror and dismay, claim but few victims as compared with this ever-present, universally devastating plague. These other plagues are quick, severe and fatal, it is true, but for this very reason they can be promptly recognized, and checked and even stamped out, whereas tuberculosis is equivocal and underhand in its method, slow and uncertain in its progress, and on this account escapes recognition and proves by far the most deadly of any single disease attacking the human family. The average ratio of deaths from tuberculosis to the total mortality is 14 per cent., or one death in every eight, while under special conditions it rises to one in three, as in the Marquesas Islands, or even one in two, as in some of our Indian reservations. Tuberculosis may be classed with "the pestilence that walketh in darkness, "while the the three other diseases named are like "the destruction that wasteth at noonday." But the deaths from tuberculosis being constant and uniform, people accept them as inevitable and fold their idle hands with true Mohamedan fatalism instead of boldly exposing the hidden deathtrap, and cutting short its destructive work.

If the 5,490 deaths from tuberculosis which occur every year in the city of New York could be brought together in an epidemic lasting but one week, no small pox, cholera nor yellow fever scare would approach the panic which would thus be created, for

when did all three diseases together create such mortality in this city? Nay, if we take the whole civilized world and compare with the tuberculosis mortality, all the accumulated deaths from war, famine, plague, cholera, yellow fever and small pox we find that the latter are comparatively very insignificant. Yet tuberculosis like every germ disease is absolutely preventible, and is allowed to continue its career of death only because of reprehensible ignorance and criminal indifference.

ITS PREVALENCE IN THE LOWER ANIMALS.

Few if any diseases maintain a sway over a more numerous genera of animals than tuberculosis. Among the domesticated animals cattle are perhaps the most susceptible, but chickens, guineapigs, rabbits, swine and goats become victims almost if not quite as easily. Some have thought that dogs, cats, sheep and horses are exempt, but when inoculated with tuberculous material these all contract the affection readily enough. The fact that they do not contract it in such numbers in the usual way is probably due in part to the greater amount of outdoor life which they enjoy, also to the fact that they have more exercise which secures for them a better developed and higher conditioned muscular system, and a full stock of constitutional vigor. After making all these allowances, however, it must be granted that these four classes of animals enjoy a native intolerance to this disease to which the first six classes mentioned are comparative strangers.

Among the less domesticated animals which contract tuberculosis may be named caged apes, lions, kangaroos, deer, elk, gazelle, antelope, birds, and in addition the rats, mice and other vermin of our houses and barns. All must, therefore, be considered as possible bearers and disseminators of the infection and no such animal (indeed, scarcely any animal) can be left out of account in any systematic attempt to root out the disease. Some, however, are justly held to contribute more than others to the maintenance of the affection, and in this sense, in addition to man himself, we must consider as preëminently bearers of this disease cattle, fowls and pigs.

Accurate statistics are wanting to give the rates of tuberculous animals in our herds, as we have no systematic professional

inspection of live animals and of those killed for human food. Even in the large cities of Europe when such inspections are obligatory, in the case of carcasses, the data given are so variable as to suggest the acceptance of different standards in the various cities and countries. Thus tuberculous cattle are said to number: In Bavaria 0.225 per cent. (Goring), in Augsburg 0.26 per cent. (Adam), in Baden 0.2 per cent. (Lydtin), in France 0.5 per cent. (Arloing), in Belgium 0.4 per cent. (Van Hertsen), in Paris 6 per cent. (Friedberger and Fröhner), in Holland 20 per cent. (Schmidt), in Pommerania and Bomberg 50 per cent. (Schanz, Albrecht), at Hildesheim, Hanover, 60 to 70 per cent. (Haarstick), in Leipzig 20 per cent. (Rieck), in Edinburgh 26 per cent. (Cope, McFadyean). American figures given by the Bureau of Animal Industry are for Baltimore (mostly cows) 2.5 to 3.5 per cent. and for the packing centers (among 2,273,547 mostly steers) 0.02 per cent. It must be noted that the data from Baltimore is somewhat too favorable for city cows, as the cows were largely from infected dairies, where the more rapidly fatal lung plague carried off many before time had been allowed for the development of tuberculosis, and as the vacancies were speedily filled by fresh cows from country districts, the results give the ratio for country herds rather than the normal proportion for the city. The splendid showing for the steers must also be qualified by the remark that the fat and apparently healthy are alone sent to the large distant market while the unthrifty are held back lest they should spoil the sale.

Steers further largely escape on account of their out-door life with less opportunity for infection, and because they are, as a rule, killed at three years old and under, and tuberculosis becomes more and more prevalent with the advancing age of the stock. In a large aggregate number of German abattoirs, cows suffered in ratio of 6.9 per cent., oxen 3.6 per cent., bulls 2.6 per cent., and calves and yearlings 1 per cent. In Leipzig, tuberculous cows were 26 per cent., oxen 19.5 per cent., bulls 15.4 per cent., and calves 9.3 per cent.

In infected breeding and dairy herds in New York, consisting largely of mature cows I have found a maximum of 98 per cent. and a minimum of 5 per cent. Again in healthy country districts I have found hundreds of cows in adjoining herds without a trace of tuberculosis among them.

TUBERCULOSIS CONTAGIOUS.

In the middle ages tuberculosis in animals was recognized as contagious and laws were made against the use of the affected carcasses as human food, which remain in force in Italy and Spain to the present day. In the 16th century the disease was confounded with syphilis and at the end of the 18th century with glanders, blunders which, however untenable, show the strong conviction that the malady was contagious. The propagation by contagion in herd was recorded in Germany by Ruhling (1774), and Krunitz (1787), and more recently by Spinola, Zannger and others. In France the same is claimed by Fromage, Huzard, Lafosse, Dupont, and Cruzel.

It must be allowed, however, that in the first half of the present century, the manifest tendency of the disease to run in families, and to develop under special unwholesome conditions of life, served to weaken the belief in contagion, and in Central and Western Europe such belief had become practically extinct among medical men, when their attention was recalled to the subject by the successful inoculations of tuberculosis on rabbits and guinea-pigs, by Villemin, in 1865. The subject was taken up on all sides by incredulous experimenters and for a time a keen polemic warfare raged, but slowly the stern logic of constantly accumulating and unanswerable facts compelled all candid observers to accept the doctrine of contagion.

THE GERM. BACILLUS TUBERCULOSIS.

An even fuller demonstration came in 1882, when Robert Koch, of Berlin, demonstrated the existence of the tubercle bacillus, and showed that the disease could be produced with equal certainty by inoculating with the substance of a tubercle from the ox's lung, or with a pure culture of the germ grown on peptonized gelatine, apart from the living body. Before publishing his discovery Koch demonstrated the presence of the bacillus in the expectoration or tubercle of over 100 cases of consumption, and had successfully inoculated 472 subjects—guineapigs, rabbits, mice, rats, and cats, besides dogs, pigeons and chickens. The following are some of the characteristics of this germ :

Form.—A delicate rod with rounded ends, 1.5 to 3.5 micromillimeter in length (about 1-2500th of an inch). They occur singly, or in pairs or chains

of three or four connected end to end. When cultivated on blood-serum the groups tend to form elongated rope-like colonies, having a waving or serpentine outline.

Staining.—It is characteristic of this bacillus that it absorbs coloring matters very slowly and once stained retains its color with great tenacity. This enables the microscopist to distinguish this amid a mass of other microbes. The opaque particles in sputum or a section of the tubercle is stained by prolonged exposure to a warm alkaline solution of an aniline pigment; it is then bleached by a solution of nitric acid (1:3); it is then washed and slightly stained with a color which will contrast with the first; finally it is washed, mounted and examined under the microscope. The rod-like bacillus tuberculosis appears stained with the first color while the other bacteria, if any, are stained with the second.

Biology, Life-history.—The bacillus tuberculosis lives mainly as a parasite in the animal body, but may be cultivated on the ordinary culture media containing 5 per cent. of glycerine and makes the best growth at 100° to 102° Fah. A temperature of 158° Fah. for ten minutes is fatal to it (Versin). Unlike many bacilli this shows no spontaneous movement at any stage of its growth. Its development is slow in any medium, the earliest signs of growth being visible only after ten or fourteen days.

Vitality.—As it has great power of resistance to the entrance of coloring fluids, so this germ can hold its own for a length of time against destructive agencies. It retains its vitality and infecting power for nine to ten months in dried expectoration (Koch, Schill, Fischer, De Thoma). In tuberculous cow's lung, dried and pulverized, it infected Guinea pigs after 102 days. In putrid matter it infected after 43 days (Schill, Fischer) or 102 days (Ca-deac, Malet). It is not destroyed by gastric juice (Baumgarten, Fischer, Falk).

In sputum it perishes in 20 hours in a 3 per cent. solution of carbolic acid in a saturated aqueous solution of salicylic acid or in saturated aniline water (Schill, Fischer); in five minutes by iodoform ether; in ten minutes in sulphuric ether or mercuric chloride (1:1000); in three hours in thymol. It dies in a few hours in direct sunlight, and in five to seven days in diffuse daylight (Koch). In an ordinary room it gradually weakens but remains virulent for at least 2½ months (Sawiskey).

INDESTRUCTIBILITY OF THE GERM.

Drying and heating—The substance of a tubercle, like expectoration, may be dried up and reduced to powder without lowering its virulence provided too much heat has not been employed in the drying. Although an absolute heat of 158° Fah. for 15 minutes is fatal to the germ yet in virulent masses, as in meat, it is difficult to determine the actual temperature at all points and tests are therefore often misleading. Thus Toussaint found that broiled steak, the interior of which by his tests had reached 163° to 176° Fah. was still infecting. Martin heated tuberculous matter in sealed tubes to 212° Fah. and found that even then some germs would exceptionally escape. Chauvean and Arloing found that nothing survived half an hour of the boiling temperature and Galtier found that 162° Fah., which coagulates albumen, sterilized completely if kept up for a sufficient length of time. If in cooking meat, the blood (albumen) is not coagulated but oozes out as a red fluid the temperature has not been enough to ensure the death of the bacillus. Where there is a risk of tuberculosis therefore *rare* steaks must be refused.

In milk as in meat heat is effective but at 162° Fah. the continued albumen is coagulated, the liquid acquires the boiled flavor, a tendency to constipate, and a diminution of its digestibility and nutritive qualities. In sterilizing this liquid, therefore, for infants and invalids, it is better to keep the temperature at 158° Fah. for a longer period, say half to one hour continuously.

Drying of the tuberculous matter in doors or in the shade, and apart from the above temperature, and its inhalation as fine dust is one of the most common causes of tuberculosis. In one store with a tuberculous clerk the dust raised in sweeping out the store infected clerk after clerk, and a similar rising of the virus in dust is a cause of infection in dwelling houses, stores, barns, barnyards, stockyards, and railroad cars. It is now allowed that the infecting matter dried on the handkerchief, and shaken out on the air is one of the most prolific sources of infection. So in animals, a manger smeared with the discharge of a diseased animal, retains the virus in an infecting state and infects the next susceptible animal fed from it. Hence long before the days of Koch and his discovery of the bacillus, the infection of animal after animal which occupied the same stall in succession had convinced ob-

servant stock owners and veterinarians of the contagion in tubercle.

Survival in Water and Moist Earth.—Galtier found that the bacillus tuberculosis was preserved indefinitely in springs, ponds and wells at all ordinary temperatures. Hence the danger of common drinking troughs, of streams that have run past infected herds, or the places where their manure has been put and of soil that have received the manure or carcasses of the deceased. The danger from soils is less from dust blown from the surface and which has been presumably devitalized by prolonged sunlight, than from the earth that is pulled up attached to the roots of the turnips, beets and carrots or to tubers like potatoes. Grain crops may therefore be grown with greater safety on infected soils, than can root crops.

Freezing.—The germ survives a freezing temperature. Galtier kept tuberculous matter at different times in a frozen state for four and five days respectively and found it still infecting. Neither the winter's frost, therefore, nor the usual alterations of temperature in the soil can be trusted to speedily disinfect it.

Putrefaction is not fatal to the germ (Cornil, Babes, Mallassez, Vignal, Galtier, etc.).

Heavy salting of meats has been thought to be fatal to the germ in one month. After fifteen days in salt the germ failed to kill rabbits but still killed the Guinea pig, whereas after thirty days it killed neither (Galtier). In salting, however, the meat is impregnated unequally in different parts of the same mass, and therefore, as in the case of a temporary heating, this cannot be relied on as a safe measure of disinfection.

The comparative indestructibility of the germ under any of these conditions, shows that the slow absorption of pigments by the bacillus, is significant of an equally tardy penetration by other hurtful agents, and of a corresponding power of resistance to ordinary disinfectant agents.

ACCESSORY CAUSES OF TUBERCULOSIS.

While all must to-day recognize that the one essential cause of tuberculosis is the bacillus, yet it is wrong to ignore the fact that many conditions of the animal system and its surroundings contribute to the propagation of the disease, or retard its progress.

While none of such accessory causes can generate tuberculosis in the absence of the bacillus, yet when that diseased seed is present, these conditions often serve to sway the balance toward its advancement and diffusion, or its restriction and suppression. A suitable soil and favorable climate is no less essential for the vigorous growth of the microscopic vegetable microbe, than for the Florida moss or the palm.

Among the most efficient accessory causes may be named :

a. Hereditary Predisposition.

Consumption runs in families and it has long been supposed that this was essentially a family—that is, a hereditary disease. But as a matter of fact it is extremely rare to find the offspring tuberculous at birth or before. In many thousands of pregnant tuberculous cows killed in the slaughter-houses of Europe not more than ten tuberculous calves have been found. To the same effect is the fact that in calves under a year old, born of cows, six per cent. and upwards of which prove tuberculous, the ratio of tuberculosis is often below one per thousand. In Saxony with the ratio of tuberculous cattle 16.5 per cent. that of tuberculous calves was only 2 per 1000. At Lyons out of 400,000 calves slaughtered only 5 were found tuberculous and at Munich out of 400,000 but 2 tuberculous. Again in such calves the tubercle is found in a very large proportion of cases in the bowels and adjacent glands suggesting infection after birth through the milk, rather than in the liver and lungs which would have been its natural seat if conveyed before birth through the blood. Not a few of the obstinate and fatal bowel diseases of sucking children and calves are in reality tuberculosis of the bowels induced by the infected milk.

What runs in a family then is rarely hereditary disease :— it is in the great majority of cases only a hereditary susceptibility to the disease, tuberculosis. But it is none the less a fearful legacy, being often so potent that the disease attacks certain families as a matter of course, while other families can count on a practical immunity. In the human family this is notorious. In cattle it is no less remarkable. In the Burden herd of Jerseys in 1877, I made examinations, and condemned eleven animals, verifying my diagnoses by examinations after death, and found to my

surprise that I had taken every representative of a given family, and left the pure bred members of the second family untouched. Both families had mingled freely in the pastures and yards, yet the second family furnished no tuberculous cases and remained sound from that time onward.

b. Close Buildings, Lack of Ventilation.

Air rendered impure by repeated breathing is so favorable to the propagation of tuberculosis that it has been looked upon as the sole cause (Macormac). Though now certain that this cannot produce tuberculosis at all in the absence of the germ, yet it is such a potent accessory cause when the bacillus also is present, that its importance cannot be too highly appreciated.

For the mild cases of tuberculosis in man life in the open air, day and night, in a genial climate with pure air affords one of the best grounds of hope of recovery or mitigation. In the Burden herd above referred to, animals condemned in the spring spent the summer at pasture, with a general appearance of perfect health, yet, when returned to the barns in the fall, they fell off so that soon some of them had to be helped to rise in the stall. All the world over city dairy cows are notorious for tuberculosis. In Europe where the country cattle are affected in a ratio of 1 to 2 per cent., those in the city dairies suffer to the extent of 6 to 20 per cent. and upward. Of our plains and prairie steers the government inspectors, at the abattoirs, condemned as tuberculous but 0.02 per cent., whereas of the city dairy cows, mostly recently from the country, they condemned 1.23 per cent. The ratio is 1 steer to 60 cows, a most striking showing in favor of an open air life.

c. Dark Stables.

Dark stables are usually dirty and ill-ventilated, and as such, lower the general health of the inmates and strongly predispose them to tuberculosis. The darkness, however, acts indirectly in depriving the tissues of the body of their due supply of air. The formation of green pigment (chlorophyll) in plants, and that of red pigment in the blood globules are alike due to the action of light. In darkness both disappear. But the red globules of the blood are the bearers of oxygen to all parts of the body, and if these globules are deficient the whole body is denied its due

eration. The final result is as if the air contained little oxygen, in other words, as in the case of a close building without any means of renewing the air.

d. Insufficient or Unwholesome Food. Overtaxing.

Lack of food, and indigestible, or innutritious food, agree in producing practical starvation and weakness with increased susceptibility to tuberculosis. Hence, this disease is the scourge of the half starved poor, and no less of the rich who abuse their digestive organs, and court chronic dyspepsia. So, too, in our dairy herds the stimulating ration-for-milk, the warm drinking water, and warm atmosphere, together with the enforced rest in the stalls for months at a time, and the clean, careful milking soliciting the gland to act to its extreme capacity, all tend to a lowering of the general health and an increased susceptibility. This sufficiently illustrates how the cow which has been made a milking machine, and which to this end must produce a calf every year, becomes dangerously susceptible to any tubercle bacillus to which it may be exposed. We have developed most valuable qualities at the expense of hardihood, and we must take the consequence. The argument is not that we should part with acquired powers which give the animal its high value, but that we should recognize the attendant dangers and rigorously exclude the tubercle germ.

e. Breeding too Young.

Breeding of immature animals is a most fruitful accessory cause of tuberculosis as the demands made upon the system for further growth, for the nourishment of the unborn offspring, and later for the nursing of the calf, or for the dairy yield, undermine the strength and vigor. In different families of that marvelous dairy cow, the Jersey, this has been carried to such an extent that discredit has been thrown upon the whole breed as one especially prone to tuberculosis.

f. Inbreeding. High-breeding.

Inbred families of cattle are proverbially subject to tuberculosis. This is due partly to a resulting constitutional weakness, which often shows itself in an increasing indisposition to breed to near relatives, though still fertile with strangers. More frequent

ly, it depends on the intensifying and fixing of personal and family characters. The susceptibility to the germ being equally strong in both parents becomes intensified in their common offspring just as the beef or dairy characteristics are improved. Indeed, the qualities which make an animal valuable for the butcher or milkman are exactly such as favor tuberculosis. The germ of this disease lives by preference in the lymphatic system, either in the lymphatic glands or in the loose connective tissue forming the lymphatic networks leading to these glands. Now the breeds which are preëminent for early maturity, and rapid fattening, or for a high yield of milk are remarkable for their excess of connective tissue, as shown by the delicate mellow skin, and in the case of the Channel Island cattle by the unusually large lymphatic glands. This helps to explain why certain families of beef-making cattle have been virtually ruined by tuberculosis. Yet it would be equally wrong to abandon the improvement of our beef and of our milking breeds. The improvement already attained is essential to successful competition in the market, and prospective improvement will be no less essential in the future. The true and only real remedy is the extinction and exclusion of the bacillus of tubercle.

g. Ill Health.

All acute and chronic diseases leave the system weak, and with less power of resistance to other diseases. Above all we must fear long standing diseases which produce emaciation and weakness, fevers which interfere permanently with the blood-forming processes, diseases of the digestive organs, which hinder the requisite preparation and absorption of nutritive elements, and diseases of the lungs which form a raw or weakened surface on which the bacillus can grow without hindrance. Again the germ lives best in a slightly alkaline or neutral medium, and is weakened in the acid contents of the stomach during vigorous digestion. But in indigestion the contents may be too much lacking in acidity to prove hurtful to the germ, and the imperfectly digested morsels, enclosing the bacillus, may be passed on unchanged into the alkaline intestine, a field especially favorable to the development of tuberculosis. Again in the intervals between meals when the acid secretion is arrested, the bacillus in drinking

water may easily pass through the sentinel stomach to develop in the intestines.

h. Chemical Poisons in the Tuberculous Body.

The soluble chemical poisons in meat and milk of consumptives will be noticed later as a potent cause alike of susceptibility to tuberculosis and of its more rapid progress when already in the system.

LESIONS AND SYMPTOMS OF TUBERCULOSIS.

Tuberculosis appears under two great types: the acute and the chronic, the first of which may run a fatal course of four to six weeks, while the second may last for many years. At the outset in the acute form, and for a great length of time in the chronic, the disease-process may be confined to one organ or to one region of the body and therefore the symptoms may vary exceedingly according to the particular organ attacked. In many chronic cases, with the tubercles confined to one organ or locality (lymphatic glands, liver, spleen, pancreas, etc.) the victim may be in good condition and no sign of disease may be recognized by the owner or even the veterinarian. In acute cases on the other hand and when the tubercles are generally diffused through the body, there is usually fever, wasting and emaciation in addition to the characteristic symptoms of disease in particular organs.

The lesions being caused by the colonization and local multiplication of the bacillus they tend to assume a rounded or nodular form, from which has been derived the name of tubercle. Such nodules may, however, be absent, the diseased product, being a diffuse infiltration and thickening of the affected part. The early nodule may vary in size from a millet seed up to a pea or more. It is at first red, congested and firm; soon it may become gray in the center though still red outside. With the grayish discoloration comes a gradually extending death of the mass (coagulation necrosis) and disintegration into a more or less soft cheesy looking material (caseation). In cattle and chickens this cheesy nodule tends to remain firm and it may even become gritty through impregnation with earthy salts (calcification). Exceptionally it will soften into a semi-liquid whitish debris, resembling an abscess, and this excessive softening is the usual course of tubercle in swine. In some cases however the tubercle does not break down

into a dead cheesy mass but develops into firm fibrous rounded nodules hanging in clusters from the lungs, inside of the ribs, or skin, and known as pearl disease (perl-knoten), grapes, etc. This form is particularly common in cattle. In man may be found nearly all forms of the disease, the primary hard red congested nodule, the same with its grayish disintegrating centre, the firm caseated mass, the same further softened into a white or yellowish semi-liquid pus-like mass, and in addition an open unhealthy sore caused by the breaking down of the tuberculous growth on the skin (lupus), or intestine, etc. Similar tuberculous sores are found on the skin or mucous membrane (bowels, throat) of cattle and other animals. In all the many forms and seats of the disease the bacillus may be found in the affected parts, and the morbid discharges from the lungs, skin, open sores, etc.

SYMPTOMS IN CATTLE.

a. Tuberculosis of the lungs.—In the chronic cases which are by far the most common this may last for months and years unperceived; in acute cases it may prove fatal in a month.

In recent, slight, chronic cases there may be no other ground of suspicion than an occasional cough when the animal leaves the hot stable for the cold outer air, when it is suddenly raised in the stall, when it is run for a short distance, when it drinks cold water or eats dusty food. The cough is usually small, dry, wheezing, and may be repeated several times. When run or driven rapidly the animal proves short winded. Yet it may show as good spirits, as clear, full an eye, as smooth glossy a coat, as supple and mellow a skin, as good an appetite, as rich and abundant a flow of milk, and as much propensity to fatten as its healthy fellows. An accomplished diagnostician may detect altered sounds on percussion and auscultation of the chest, but from the difficulty introduced by the heavy muscular shoulder, the frequent variations in the size of the heart, the rumbling and crepitating sounds from stomach and bowels, which, according as they are full or empty, press forward and diminish the size of the lungs, and greatly mask or modify the results, even the able practitioner cannot be trusted to detect these, and the case fails to be recognized. There may be a flow from the nose in which bacilli should be detected by the microscope, but cattle have a habit of cleaning

the nose with the pointed tongue, so that the virulent particles are difficult to secure, and when secured they prove to contain few bacilli so that a failure to find these would not be so reassuring as it would be in man. As a large proportion of cases of chronic tuberculosis of the lungs are of this kind the tuberculin test, to be noted below becomes practically indispensable.

When the lungs become more extensively involved symptoms are more distinct and reliable, and the animal usually falls off in condition, yet in many cases cattle in good condition are killed for beef and the lungs and ribs are found to be literally covered with clusters of fibrous tubercles (grapes). Usually in advanced cases the hair is dry, lustreless, and erect in patches, especially along the back. The skin is dry, powdery, and rigid without its customary mellow touch or mobility on the parts beneath. The eye is less prominent and brilliant, the breathing is more easily accelerated, the cough, more frequent and easily roused, is often gurgling or rattling and may cause a discharge from the nose of a whitish flocculent, sometimes gritty material in the flocculi bacilli may sometimes be found. The breath is heavy and mawkish. Pinching of the back at the shoulders or loins may cause wincing, groaning or cough, as may also pinching above the breastbone or striking the ribs with the fingers or fist. Percussion over the ribs reveals spots where there is a lack of resonance, apart from the solid masses of the heart, liver, spleen and stomach contents, and listening over these spots will detect that variety of morbid sounds familiar to the physician, the most prominent being rubbing, wheezing, creaking or fine crepitation, mucous rattling and various blowing sounds. A remarkable feature of tuberculosis distinguishing it from many other forms of lung consolidation attended by unnatural sounds, is the occurrence of such changes in patches with intervening spaces of sound lung. Ordinary inflammations more commonly attack one portion and spread from that as a center extending the solidification in one or all directions. Arrived at this stage the animal usually fails to make flesh satisfactorily on the best feeding, and milk is not only lessened but becomes poor, blue and watery.

The tubercles tend also to form more in other organs, notably the lymphatic glands and bowels, and digestion and assimilation being thus seriously interfered with emaciation advances

more rapidly. This advance may be largely accounted for by the fact that the infecting expectorations brought up with the cough is largely swallowed to affect stomach and bowels. The animal has now diminished, and capricious appetite, irregular, infrequent, slow rumination and slight bloating after meals. The body temperature is more variable and more frequently high than in the slighter forms.

In the advance stages of lung tuberculosis everyone can recognize the consumptive animal. It is miserably poor and wastes visibly day by day, the dry coat of hair stands erect, the harsh scurfy skin clings tightly to the bones, the pale eyes are sunken in the sockets, tears run down the cheeks, a yellowish, granular, fetid and often gritty discharges flow from the nose, the breathing is hurried and catching, the breathe foetid. The cough is weak, painful and easily roused by pinching the back or breast or striking the ribs. Tapping the ribs with fingers or fist and applying the ear detect far more extensive changes including in many cases evidences of blowing into empty cavities (*vomicæ*) and loud gurgling. Temperature may vary from below normal to 107° Fahr.

In all such cases there is extension of the disease to distant organs and symptoms as given below complicate those of lung disease. To give means of diagnosis of tuberculosis from some diseases of the lungs which most resemble it in symptoms (lung worms, hydatids, actino-mycosis, lymphadenitis, etc.,) would unduly extend this article without corresponding advantage to my present class of readers.

Tuberculosis of stomach, bowels and mesenteric glands. In young animals living on milk, tuberculosis of the bowels and glands give rise to indigestion, foetid diarrhœas, bloating, and finally enlargement of the superficial lymphatic glands and the affection of the lungs if the animal should survive long enough. In older cattle there is impaired irregular appetite and rumination, slight bloating after meals, a tendency to scour when liberally grain fed, costiveness alternating with scouring, colics, and usually a more pronounced wasting than with the lung disease. The oiled hand introduced into the last gut may detect the enlarged mesenteric glands which must be carefully distinguished from hardened faeces in the bowels from the ovaries, from masses of fat, etc.

The temperature is raised in proportion to the activity of the tubercular process.

Tuberculosis of womb and ovaries.—These and their supporting membranes or ligaments are often implicated in the bowel disease giving rise to undue generative excitement. They may also become primarily infected through coition. The affected cow is usually sterile, sooner or later parting with any ovum that may have been impregnated. Later her *heats* may become more intense and last longer, and never lead to impregnation. The cow spends most of her time wandering around, bellowing for the bull, and neglects to eat or ruminate and wastes away rapidly. There is often a whitish discharge from the vulva. The temperature is elevated and general tuberculosis sets in sooner or later.

Tuberculosis of the liver spleen or pancreas.—The liver is one of the first organs to suffer in infection through the stomach and bowels, and it may be exclusively affected in calves and even in mature animals. Tuberculosis of the liver may be accompanied by impaired appetite and digestion, bloating after meals, and in exceptional cases by jaundice, but often an indefinite ill-health is all that can be detected. Pancreatic and splenic tubercle are marked by a similar obscurity of symptoms. It is usually only when the disease begins to be generalized that distinct, objective symptoms are available.

Tuberculosis of the kidneys and bladder may be attended by extra sensitiveness of the loins to pinching and by frequent passage of urine, more or less discolored by blood or mixed with purulent matter. Examination of the microscopic blood casts in the urine after having stained them may reveal bacilli.

Tuberculosis of the throat. Pharyngeal glands.—This is one of the most common types in cattle. Attention is usually first drawn by a wheezing breathing, the sound manifestly coming from the throat, and the glands around that part are felt to be enlarged, unequal on the right and left sides, or shrunken and of a gristly hardness, or softened and even fluctuating on pressure. The formations above the throat and beneath the first bone of the neck, are particularly liable to undergo this special softening. There is usually a loose gurgling cough, some difficulty in swallowing, and a slimy discharge from the mouth. Small tubercular growths may exist on the lining mucous membrane, and this

sometimes extends into the air passages causing *tuberculosis of the larynx* with a persistent paroxysmal cough and a harsh altered voice.

Tuberculosis of the udder.—A portion of a single quarter is usually first affected, causing a circumscribed swelling, harder than the rest of the gland, but not hot nor painful, and this gradually extends to the whole udder. With this extension the gland becomes harder, and the milk lessened, more watery and clotted, and the lymphatic glands in front of the udder and behind are enlarged, and hardened. The gradual advance of the disease serves to disarm the milker of any suspicion and the milk is commonly utilized until its watery or grumous appearance draws special attention to the gland. The case may be tested by inoculating with the milk, or less satisfactorily by a microscopic search for the bacillus, or the tuberculin test may be applied.

Tuberculosis of the lymphatic glands.—In cattle the lymphatic glands are often found to be tuberculous to the exclusion of internal organs, and as this form of the disease tends to become chronic it is likely to be overlooked for a length of time. Wherever a group of these glands exists, there may be tuberculosis. In addition to those already cited may be here named :

a. *The submaxillary glands* situated on the inner side of the lower jaw at the point where the pulse is felt. These which are almost imperceptible in their natural condition, may swell up to any size, soften, burst, and discharge a cheesy matter. They are most liable to be confounded with actinomycosis of the same region but do not show the almost microscopic hard yellow clusters of the actinomyces. They yield in place the specific bacillus.

b. *The glands at the root of the ear.*—These swell in front or behind the ear, soften and like the submaxillary glands they may or may not burst and discharge.

c. *Glands inside the chest, mediastinal, bronchial, etc.*—The mediastinal and bronchial glands lying between the lungs in the centre of the chest are often affected independently of the lungs, and give no easily available symptom. A persistent nervous cough and some unthriftiness, though on good, liberal rations, may arouse suspicion, but cannot lead to diagnosis. If the *glands on the walls of the gullet (æsoophagean)* are implicated the vagus nerve and stomach may be involved and digestion, rumination,

and the eructation of gas may be interfered with so that chronic bloating may be added to the suggestive, though by no means diagnostic, symptoms. Equally obscure are the indications of disease of the *glands beneath the back bone and those above the breast bone*. Of the more superficial glands of the trunk the following are the most easily examined :

d. Glands in front of the shoulder blade.—This group is in front of the middle of the shoulder blade, and may easily be siezed in the hands in thin cattle. If enlarged unequally on the two sides, or if very hard and nodular though small, suspicion may well attach to them. It is only on rare occasions that they burst and discharge.

e. Glands above the stifle.—These placed on the side of the flank in front of the stifle can also be grasped and examined. Indeed, in certain animals, notably in the Channel Island breeds, they can be seen by the eye. Swelling, inequality, hardness, nodularity are the usual suspicious features. Often smaller pea-like or hazel-nut-like masses are found scattered over the lateral walls of the belly from the last rib to the hip bones, and even in the interval between the two last ribs.

f. External inguinal glands.—In the male the glands on the sides of the scrotum, and in the female those on the sides of the udder may be felt to be enlarged when affected with tuberculosis.

g. The posterior cervical glands situated in the lower end of the furrow that lodges the jugular vein, may be similarly implicated and recognized.

The deeper seated groups of lymphatic glands, need not be individually referred to, for though subject to tuberculosis they rarely show as external swellings. Tubercles, however, may appear in any part of the skin. I have found a caseated mass like a hickory nut on the point of the shoulder, and fibrous warty-like growths on the skin, and open unhealthy sores with hard fibrous surroundings may be fibroid tubercle.

It must be borne in mind that the lymphatic glands are liable to become congested and inflamed from other sources of irritation in themselves and in their vicinity so that the mere fact of disease of these glands is no sufficient evidence of tuberculosis. It is however ground for grave suspicion, and further exculpatory evidence is demanded.

Tuberculosis of bones and joints.—This is especially seen in young growing animals, being common in calves in badly infected herds. Wm. Mueller has produced it experimentally by injecting the nutrient artery of the bone in a three month's goat. The bones most commonly attacked are those entering into the formation of the elbow and knee, the stifle and hock, and as the disease usually extends from the gristly growing substance in the bones of the joint surface, the trouble is recognized as disease of the joints. In some instances, however, the disease begins in the lining membrane (synovial) of the joints and forms fungous growths extending into the bone. In the open (cancellated) tissue on the end of the bone it is at first red and congested, later it is partly fatty, and caseated. Usually the disease becomes general, but if it remains circumscribed, it is enveloped in a layer of dense hard bone. The animal is very lame, perhaps even unable to rise, the joints swollen and tense, and the ends of the bones enlarged and tender. The disintegrated bone may even crumble and the sharp spiculae protrude through the skin.

Further Indications of Tuberculosis.

The above outline of symptoms seen in cattle is rendered necessary by the invariable question, "how can I recognize it?" The intelligent reader will realize from the partial sketch above, that it is no simple matter to diagnose tuberculosis. It is to be hoped that he will also have apprehended so much of the subject as will save him from being victimized, by the man who boasts loudly, but really knows little.

In the multitude of equivocal and occult cases further tests must be applied. These may be named as (1) microscopic search for the bacillus, (2) inoculation, and (3) injection of tuberculin.

Inoculation.—The first named test having been already incidentally referred to, inoculation may be noticed. This consists in the introduction into the peritoneum or other part, of a guinea-pig or other animal or some of the suspected product (discharge from the nose, milk, juice from an enlarged gland, etc.) General abdominal tuberculosis should be present in the guinea-pig in 30 days. Beside the delay, this has the draw-backs, that the guinea-pig may have been already infected before the inoculation, the portion of the suspected product may have been devoid of bacilli

though these were abundant enough in the animal from which it was taken, or the guineapig may have become infected after the inoculation from being kept in an infected place, or from infected food, water, attendants, etc. We must first secure for the guineapig the very guarantee we are seeking for the larger animal. Is it not then better to secure this for the larger animal first and avoid all the subsequent sources of fallacy attendant on an inoculation experiment?

The tuberculin test gives prompt results and is less open to fallacy.

Tuberculin.

Tuberculin or *Koch's lymph* consists in the concentrated, sterilized liquids in which the bacillus tuberculosis has been grown. It contains no living bacillus; all germs have been killed by heating; but it does contain the chief poisons which are produced in the tuberculous body, and which bring about all the diseased processes in such body. A possible exception may be made of any such poisons as are destroyed by heat if any such there be, in tuberculous products. It must be distinctly understood that in every contagious disease there is, 1st, the germ which grows and multiplies in the susceptible animal system, but is not, in itself and by its mere presence, necessarily injurious, and, 2d, the products of the life of that germ which may or may not be poisonous. The many germs, which continually enter the animal body, have products that are not appreciably poisonous and therefore produce no disease, whereas the few that do manufacture poisonous products cause our different contagious diseases. We find a counterpart in the yeast germ which in itself is virtually harmless to man, whilst the alcohol, which it manufactures from sugar under certain conditions, is a poison more or less hurtful according to the susceptibility of the person taking it.

Tuberculin consists of chemical poisons which the bacillus secretes or manufactures, and on which the force and all the manifestations of tubercle in the tissues are chargeable. Having no living germ it cannot increase its own substance, nor can it cause tuberculosis in a healthy system as it is soon thrown out of the body through the kidneys and other channels and its power for evil is at an end, yet none the less is it the immediate agent

through which all the destructive work of tuberculosis is carried on. Where the bacillus tuberculosis lives and multiplies in the animal body these chemical poisons are being constantly formed, and thus its pernicious action is continuous, not only in the seat of the tubercle but through the whole system.

Tuberculin as a Test.

The tuberculin test is based on the fact shown by Koch that it increases the activity of the disease process in tubercle, and affects the whole animal body producing a reaction or rise of temperature in a marked degree. On the ordinary tubercle as seen on the surface, the frequent use of tuberculin produced a more active process of cell growth leading to degeneration and death, so that there was a more speedy transition from the red congested nodule, through the grayish degeneration into the dead cheesy mass, cut off from all blood circulation. If this dead mass were sloughed off leaving sound tissues to heal, that particular tubercle might be cured. But deeper tubercles usually exist and these are similarly stimulated and their degeneration hastened by the tuberculin; it is impossible for them to be cast off; the increasing masses of bacilli, which have been produced under the rapid growth, are shut up in the solid tissues around to furnish new seed for a fresh extension of the disease. As such deep seated tubercles usually do exist with superficial ones, they render tuberculin almost useless as a curative agent, since to eradicate the disease the deep caseated tubercles must be afterward removed by surgical means, a resort which might have been had at the beginning and without the use of tuberculin.

But this action which renders tuberculin so objectionable as a curative agent makes it of the highest value as a test of tuberculosis in animals. The minute dose which has no effect on a healthy cow, horse or pig, when employed on the slightly tuberculous one produces an acceleration of the disease process and in eight to fifteen hours a material rise of temperature. This has been now employed on thousands of cows and those who have used it most, value it the most highly, whereas many who at first reported reactions in non-tuberculous animals are now acknowledging with Nocard that the fault has been mainly their own, for small tubercles were present but were overlooked through their failure to examine the bones and other organs.

The explanation of the reaction under tuberculin may be very simply stated. The dose is made so small that it will not affect a healthy cow under ordinary conditions. In the slightly diseased cow the system contains a certain amount of tuberculin produced by the bacillus in the tubercles, but to this the system has become accustomed and it causes no very appreciable fever. But when in addition to this we introduce into the body of this cow the small amount of tuberculin, used for the test, the increased dose acts on tubercle and nervous centres alike and a fever is produced. So evenly balanced has been the tolerance acquired, and the amount of poison tolerated with impunity, that four drops of tuberculin will as a rule produce this elevation of temperature in the moderately tuberculous cow.

Objection to Tuberculin as a Test.—1st. The temperature sometimes rises in a non-tuberculous cow after the use of the tuberculin.

This is true. So does the temperature sometimes rise in a non-tuberculous cow when no tuberculin has been employed. Every animal is liable to suffer from inflammation and fever, and if such inflammation and fever set in after the use of the tuberculin test they are liable to be charged to it as their cause. This is a valid argument against the reckless popular use of the tuberculin, but surely not against its use in skilled hands. The person who uses the tuberculin on cattle must be a trained veterinarian, acquainted with the different diseases of cattle and on his guard against confounding any one of these with the temporary fever caused by tuberculin in the consumptive. If it is claimed that every rise of the body temperature after the use of tuberculin must necessarily demonstrate the existence of tuberculosis, then truly tuberculin will be discredited. But if it is held rather that a rise of temperature after tuberculin, in a cow that furnishes to the most careful and skillful comparative pathologist no evidence of other disease, implies the existence of tuberculosis, the claim is substantially correct. To secure the valuable testimony of tuberculin, the practitioner must be highly skilled in the diseases of the animal operated on. If he is not he will be occasionally misled.

Again *heat* or *bulling* may come upon a cow after the use of the tuberculin and the temperature will rise two or three degrees. To call such a cow tuberculous would be inexcusable careless-

ness. Yet the condition demanded, the rise of temperature after the use of tuberculin, is present.

Again a cow that is closely approaching calving has the temperature raised. If tuberculin has been used it is often raised higher than it would be otherwise. It is therefore improper to use this agent on a cow at this period.

Active exertion, exposure in the hot sun, confinement in a close building, the privation of water at the customary time and other conditions will cause rise of temperature. But such a rise would not imply tuberculosis, even after tuberculin.

Apart from these and other such causes of error in unskilled hands, the rise of temperature under this test should be taken not as a condemnation of tuberculin, but as a stimulus to search for small occult tubercles. A thorough search will rarely prove fruitless.

2nd. The temperature sometimes fails to rise under the tuberculin test, though the animals be in the last stages of tuberculosis.

This also is true. Here the body seems to be already so saturated with tuberculin, that the small addition made in the test makes no impression, and if we trusted to the reaction alone, we would pronounce the cow free from the disease. But such cases are easily diagnosed without tuberculin. Even the unskilled more than suspect them, and a physical examination by the skilled practitioner leaves him in no doubt as to their condition. To use tuberculin on such cows is to waste an expensive agent and to run the risk of being misled. Objection based on blunders of this kind is valid enough as an argument against the use of tuberculin by the ignorant and thoughtless, but not against its use by an able practitioner.

3d. Tuberculin causes reaction in even the slightest cases of tuberculosis, in which the victims would survive for years and might recover.

This charge is also true, and it is because of its truth that tuberculin is invaluable and indispensable as a diagnostic agent, in all attempts to put an end to the disease. An eminent German professor (Eggeling) in objecting to the use of tuberculin as a general test records the following experience. In a herd of 37 reaction after tuberculin occurred in 31, while 6 gave no reaction. When

killed the 6 proved sound and the 31 without exception tuberculous. But of the 31 only 1 had general tuberculosis and was condemned as unfit for food, and 1 was sold as second-class meat. The 29 brought first-class prices as meat, and having been only slightly affected would probably have lived for years without infecting others. Now it is submitted that the German standard as thus given is not radical enough to secure safety for man or beast, nor to give hope of an early extinction of tuberculosis. The meat of the animal with two or three tubercles in one organ is generally, but by no means always, free from the germ. When the disease does extend from such isolated tubercles, as often happens, the germ is carried not only in the lymph, but in the blood, and with tubercle in the body no one can tell when the bacillus has passed into the circulation and reached the different organs. Tubercles usually form slowly and the bacilli must have been in the blood for some time before they show as fresh tubercles in tissues and organs distant from the old ones. The meat of a tuberculous animal can never therefore be fully guaranteed as safe to eat. But again, while a cow with one or two tubercles only in lymphatic glands, may not be liable to transmit the disease to others, yet whenever an extension takes place, the germs being carried by the blood and therefore throughout the whole system, there must always be danger of their escape from the natural surfaces (lungs, udder, liver, bowels, etc.) to infect other animals. And let it be borne in mind, this diffusion through the blood takes place before its occurrence is revealed by the formation of tubercles in new situations. So long, therefore, as a single victim of even slight tuberculosis is left in a herd it can only be looked upon as an invitation to a renewed extension of the disease. It also may become at any moment a source of infection for man through the use of the meat or milk. It is only in degree that the contagion of tuberculosis differs, as to its sanitary aspect, from that of any one of the more contagious diseases, and in all alike so soon as we attach more importance to the preservation of an infected animal that will probably recover, than we do to the radical extinction of the disease, we undermine and destroy the effectiveness of our sanitary work. Practically all cases of foot and mouth disease recover; yet the frequently recurring epizootics of this disease each cost from \$5 to \$10 per head over the entire

bovine population. Of the victims of Rinderpest and Lung Plague that do not speedily die practically all recover. Are the slighter cases therefore to be kept alive to perpetuate indefinitely those disastrous visitations that sweep away values of hundreds of millions? Is the remorseless scourge of tuberculosis to be perpetuated, not only in herds, but in our homes as well, to save for a few months or years some tuberculous cows? No country has ever dealt successfully with any of these animal plagues on the basis of preserving the mild cases for recovery. Always and everywhere it has been by the radical and thorough extinction of the disease germ wherever found, that success has been achieved. While this cannot be done for man, it must be done for our flocks and herds if we would ever cut off this prolific animal source of tuberculosis from the human race. Even as regards the herds themselves the stockowner who would consult his own future interests, would at any cost exclude from his barns and fields every possible source of future tuberculosis.

As will be shown below the meat and milk of tuberculous animals contain tuberculin (even when they do not contain the bacilli), and serve to aggravate any existing or latent tuberculosis in man.

4th. A fourth objection to the tuberculin test is its alleged liability to produce tuberculosis in healthy animals, or to aggravate it in the tuberculous ones.

Now tuberculin, properly prepared is absolutely sterilized, so that it can plant no living germ nor start the growth of any tubercle in a healthy animal. The further claim that it aggravates tuberculosis which is already in existence, is too true, and is the sound basis of its value as a test. As a means of testing the existence of tuberculosis in man it cannot be too strongly condemned, since no man has a right to seal the fate of his fellow for the sake of finding out if he has tuberculosis. The same condemnation must be passed on the use of tuberculin as an alleged curative agent, except in those few cases in which the tubercle is confined altogether to the surface of the body, whence it can easily be sloughed off. The existence or possible existence of an internal or deep-seated tubercle in man should forbid the use of tuberculin for diagnosis or for curative purposes.

The same remark would apply to animals if we adopt the Ger-

man view that it is impolitic to destroy those that are only slightly affected. If tubercle exists, to however limited an extent, tuberculin tends to aggravate it, and the owner who wishes to preserve his mild cases cannot desire to have them made worse, which means to have the disease extended and possibly generalized.

So in government sanitary work. Unless the government is prepared to slaughter and pay for every animal affected with tuberculosis in however slight a degree, it has no right to use a tuberculin test. It is only when the State means to make thorough work in eradicating tuberculosis from the herds that the tuberculin test is at all admissible. But when the State aims at the thorough extinction of the disease in our herds this test cannot be omitted, as it is absolutely essential to success. The temporary aggravation of the disease is no possible harm, when the animal is to be promptly killed and paid for.

To sum up: The tuberculin test aggravates existing tuberculosis and is, therefore, unwarrantable for use on man or on cattle that are to be kept alive; it is, however, the only known means of detecting many occult cases of tuberculosis and is, therefore, indispensable in any systematic effort to *stamp out* the disease by the purchase and slaughter of every tuberculous animal.

MEAT AND MILK OF TUBERCULOUS^u ANIMALS UNFIT FOR FOOD.

In this connection we must consider two questions essentially distinct from each other and equally important in a sanitary sense. The first is the question of *infection* by the use of such food products, and has been very fully investigated by pathologists and sanitarians. The second question—is that of *poisoning* by the pernicious products of the germ and has hitherto been entirely ignored by sanitary writers and administrators. It will be convenient to consider these questions separately.

I. INFECTION BY BACILLI IN MEAT AND MILK.

First however it will be instructive to compare the geographic distribution of cattle and that of tuberculosis, not with the view of showing that most of the tuberculous infection of man comes from cattle, for it probably comes mainly from his fellowman, but to demonstrate rather that in some way the intimate relation of cattle to man is a potent agent in the extension and maintenance of consumption in the human family. To the student of this

subject it is plain that where cattle are few or absent consumption is relatively less prevalent in man. In northern Norway, Sweden, Lapland and Finland where reindeer constitute the chief farm stock, about Hudson Bay and in the islands of the Pacific where no cattle exist, and in the Scottish Hebrides, Iceland and Newfoundland where cattle are few, tuberculosis is far less prevalent in man. In Algiers (a resort of consumptives) the cattle are few and live in the open air apart from the cities and tuberculosis does not increase among the natives. In Italy (another resort of consumptives) where cattle are housed, tuberculosis has become the scourge of man and beast (Perroncito). In Australia (a great resort for the English consumptive) the disease, formerly unknown, has become exceedingly prevalent, and the same is becoming true of our own Minnesota formerly so lauded as favorable to weak lungs.

In the temperate regions of Europe and the United States at least every eighth death is due to consumption. Dr. Biggs tells us that in New York City every fifth death is from tuberculosis of the lungs. He adds that in the Charity hospital of the city 30 per cent. of all deaths show old lesions of tuberculosis now become stationary. He quotes a Vienna hospital pathologist to the effect that he finds similar old stationary lesions in 85 per cent. of all post mortem examinations. This leaves but 15 per cent. who have not suffered from tuberculosis.

But our Northwest Indians furnish the most striking illustration of infection derived from cattle and fostered in man by unhygienic surroundings. Dr. Treon in the *American Practitioner* describes the poor emaciated diseased animals furnished to the tribes, how the Indians eat the liver, tallow and entrails raw and fresh, and how the carcass is dried, pounded and packed in the skins to be eaten later without cooking. The meat is eaten even though the animal may have died of disease. Dr. Holder in the *Medical Record* (August 13, 1892) gives the Indian mortality from consumption as 50 per cent. of all deaths at Green Bay, Wis., Tulalip, W. T., and Western Shoshone, Nev. He says that at Lower Brulé, Dak., scrofula is present in 60 per cent. of the Sioux under 21 years and that at Crow Creek, Dak., 50 out of a total Indian population of 1,200 die yearly of consumption and scrofula. Taken

along with half as many deaths from other causes this would kill the whole 1,200 in 16 years.

These are extreme examples it is true, in which the transmission and fostering of the disease by cattle, is extended and aggravated by overcrowding and every imaginable unhygienic condition, among the human consumers.

Experimental Tuberculosis by Feeding.

The experimental transmission of tuberculosis by feeding tuberculous products was demonstrated by Villemin, Günther and Harms, Zurn, Gerlach, Johne, Kolb, Toussaint, Chauveau, Peuch, Leisering, Bollinger and a host of others, the animals infected in this way including Guinea pigs, rabbits, fowls, swine, sheep, goats, dogs, cats and birds. Infection was by no means so constant as when inoculation was performed, yet in 322 experiments recorded by Johne 13 per cent. became tuberculous. The varying results depend on a variety of causes, among which may be named :—

1st. The relative susceptibility of the various animals experimented on. As we know this varies greatly with the genus, species, family and even the individual.

2d. The condition of the digestive organs at the time of feeding. The bacillus tuberculosis lives in an alkaline or neutral medium and suffers weakening or even death in an acid liquid like the contents of the stomach during active digestion. If therefore the subject of experiment has a strong digestion, and if infecting matter is taken only during active digestion, infection is usually promoted. If on the other hand the infecting material passes through the stomach in water or otherwise in the intervals between digestion when the stomach is neutral, if there is indigestion so that the contents are only mildly acid, and infecting morsels pass into the bowel without having been digested or thoroughly impregnated with acid, or if the stomach is overloaded so that part of its food passes on undigested, then manifestly infection is possible or probable. Again if there are raw sores on the mouth, throat or gullet or if the germ happens to lodge in the recesses of the bowels or pass down into the lungs infection may start from any such point as a center.

3d. The germ is more or less virulent according to the animal

from which it is derived. Thus the virus from the ox which proves certainly fatal to the guineapig on inoculation, cannot be successfully inoculated under the skin of the guineapig after it has passed through several generations in as many birds, but if inoculated from the bird in the abdomen of the guineapig and continued for several generations in this rodent it reacquires all its former potency (Nocard, etc.). So to a less extent with cattle; from one cow the inoculation invariably produces the disease; from another only occasionally. The same must hold in feeding.

4th. The degree of infection of the material fed has much influence. Tuberculous glands, and tubercles whether recent or caseated are of course the most certainly infecting. The blood and red flesh (in the ox) may be said to be the least frequently infecting, while the infecting power of milk will vary according as the udder is or is not the seat of tubercle. Toussaint who seems to have met with especially virulent cases inoculated successfully with the blood, nasal discharge, bile, urine, tears, flesh juice, dung, etc., of a tuberculous cow. Others like Nocard and McFadyean have failed with blood and flesh juice. The danger may be estimated by taking a middle position. It may be well to consider the blood, flesh and milk separately.

Dangers from Blood.

It cannot be denied that blood is inimical to this bacillus as to most other microbes. Even if the virus is injected into the veins in such quantity as to produce general tuberculosis, the germs become largely arrested in different organs or robbed of their virulence so that in a few days the blood is comparatively little infecting. This does not, however, do away with the fact that the injected bacilli live long enough in the blood to produce tubercles in many different organs, and the same is true when the disease extends from single primary tubercles, to a general tuberculosis; in most cases the bacilli can only have travelled through the blood. Bang found that of 20 cows in advanced tuberculosis, the blood of only two (or 10 per cent.) proved infecting when inoculated. Nocard has never succeeded in producing the disease by injecting the blood of a tuberculous ox into the abdominal cavity, yet he recognizes that as the disease extends by means of bacilli conveyed by the blood, this liquid must be infecting wher-

ever these bacilli are contained in it. As the migrating bacilli must be present in the blood before these secondary tubercles can be formed by them in organs distant from the tubercles that gave them birth, it follows that this infecting condition of the blood must precede the formation of the secondary tubercle, or general tuberculosis. While therefore it is quite true that the probabilities of infecting blood are greatly increased when the tubercles are numerous and generally diffused, it is an error to assume that the restriction of the tubercles to one organ is a guarantee that the blood is non-infecting. And when we cannot give a guarantee for the blood we can give none for any part or organ in which blood circulates.

Danger from Flesh.

It would seem as if the muscle or red flesh in cattle were antagonistic to the bacillus tuberculosis. Certain it is that tubercles are rare in the substance of the muscle. They are, however, very common in the lymphatic glands lying between the muscles, and in swine they are common in the substance even of the red flesh. The flesh of tuberculous pigs is therefore far more dangerous than is that of consumptive cattle. Even in tuberculous cattle, however, the beef is not always free from bacilli as shown especially by the crucial test of inoculating its juice. Arloing tested 10 tuberculous cattle in this way by inoculating guinea-pigs and found that the muscle from two of the cows only (20 per cent.) proved infecting, and that only 3 of the 10 guinea-pigs inoculated by the muscle juice of these two cows became tuberculous. Galtier fed two calves and two young pigs with the raw flesh of a tuberculous cow, but failed to infect them. This failure was, however, not necessarily due to the absence of bacilli, since two rabbits inoculated with juice from the same flesh contracted tuberculosis. Nocard fed several litters of young kittens on the flesh of cattle condemned as tuberculous, at the abattoirs of La Vilette and Grenelle, but none of them contracted tuberculosis.* Perroncito fed 18 young pigs from three to five months on the flesh of cattle condemned as tuberculous in the Naples abattoirs, yet none became tuberculous.

*By inoculation with the muscle juice of tuberculous cattle Nocard infected 5 per cent. of the subjects of experiment.

Two things are shown by the above : (a) that the red muscle is less frequently infecting than other parts, yet unquestionably so in some cases ; and (b) that the acid stomach juices during vigorous digestion are in some measure protective. It is equally plain that no sufficient guarantee can be given as to the safety of the raw flesh in any particular case. Then, again, the intermuscular lymphatic glands, which are favorite seats of infection, were carefully avoided in the above experiments with flesh juice, yet they always go with the dressed carcass and are eaten with its steaks and roasts. In pigs, as already noted, the muscle itself is often tuberculous.

Danger from Milk.

Milk is more to be dreaded than meat because the udder is often the seat of tuberculosis, and the milk is usually taken uncooked. The danger is enhanced by the fact that this is often the necessary and only food of the infant and invalid, in which the germ is especially liable, through weak and imperfect digestion, to escape into the susceptible bowel.

In milk, as in the case of meat, a strong, vigorous digestion does, in some measure, protect the consumer. Peuch fed a two months' pig in five days $4\frac{1}{2}$ quarts of milk drawn from a tuberculous udder, and killed in 56 days it proved quite sound. He inoculated four rabbits with the milk and all four became tuberculous. Again, in the absence of tuberculosis in the udder the milk may be little, if at all, infecting. Gerlach, who produced tuberculosis in calves, pigs and rabbits by feeding the milk, found no result from certain tuberculous cows, while others infected a large proportion. Nocard and McFadyean have been unable to infect rabbits, etc., with milk from an apparently sound udder of a tuberculous cow. The same has been my experience with milk from one cow in the last stages of chronic tuberculosis, and another having acute tuberculosis. Bollinger, Nocard and McFadyean claim that in the absence of tubercle in the udder the milk is not infecting. Whether true or not as an ultimate fact this cannot be made a rule of action, as the following will show :

Hirschberger inoculated rabbits in the abdominal cavity, with the milk of 29 tuberculous cows of which the udders were or appeared sound, and produced tuberculosis 14 times.

Bang inoculated from 63 tuberculous cows selected for their sound udders, and found the milk of 9 of them infecting. A careful microscopic examination revealed tuberculosis in the udders of three of the cows, leaving six giving infecting milk in which even after death, and with all scientific appliances no tubercle could be found in the udder. This is 9.5 per cent. as tested by the microscope after death; it was 14.28 per cent. as tested by the able veterinary professor during the life of the cows.

Ernst found 10 cows in 35 with infecting milk though the udders were sound. In 103 animals inoculated 17 contracted tuberculosis, and of 12 calves sucking the cows 5 became tuberculous.

Drs. Smith and Kilborne (Bureau of Animal Industry, Bulletin No. 3.) found the milk infecting in three cows out of six with apparently sound udders. One infecting cow, and one non-infecting one had each tubercle in the lymphatic gland behind the udder. Forty-four per cent. of the inoculated Guinea-pigs contracted tuberculosis: 1 in 5 from one cow, 8 in 10 from another and 6 in 6 from the third.

In my own experience three calves, from healthy parents, sucking the apparently sound udders of three cows with general tuberculosis all contracted the disease.

It must be allowed that calves sucking the cows run extra risk of infection through their nurses licking them and through feeding from a common trough, but there is the same danger for the ordinary milk consumer, since the cow in licking her udder is liable to leave bacilli to fall into the pail at the next milking.

Again the concentration of the bacillus in the indiluted milk of an infecting cow, renders this much more dangerous than the milk of the same cow diluted, with that of 20, 50 or 100 others. Bollinger and Gebhardt found that milk which infected all animals that took it pure, was apparently harmless when diluted with 50 or 100 times its volume of the milk of sound cows. As the bacillus can live in milk this apparent loss of virulence must be largely due to the reduction of the number of bacilli in a given measure of milk, and to their tendency to removal by adhering to the sides of the vessel during the mixing.

Tuberculous expectoration which is incomparably richer in bacilli

may be diluted in 100,000 times its volume of water and yet remain infecting. But again the glutinous saliva forms a protecting coating which strongly resists dilution.

Infection of Man Through the Milk.—Instances of accidental tuberculosis of the human being through drinking the unsterilized milk are no longer wanting.

In the practice of Dr. Stang of Amorback, a well developed five year old boy, from sound parents, whose ancestors on both male and female sides were free from hereditary taint, succumbed, after a few week's illness with acute milliary tuberculosis of the lungs and enormously enlarged mesentric glands. A short time before the parents had their family cow killed and found her the victim of advanced pulmonary tuberculosis. (Lydtin).

Dr. Demme records the cases of four infants in the Child's Hospital at Berne, the issue of sound parents, without any tuberculosis ancestry, that died of intestinal and mesenteric tuberculosis, as the result of feeding on the unsterilized milk of tuberculous cows. These were the only cases in which he was able to exclude the possibility of other causes for the disease, but in these he was satisfied that the milk was alone to blame.

After a lecture of the author's at Providence, R. I., a gentleman of North Hadley, Mass., a graduate of the Massachusetts Agricultural College, publicly stated that his only child, a strong, vigorous boy of one and one-half years, went to an uncle's for one week and drank the milk of a cow which was shortly after condemned and killed in a state of generalized tuberculosis. In six weeks the child was noticeably falling off and in three months he died, a mere skeleton, with tuberculosis of the abdomen. The father could trace no tuberculosis among his near ancestors, but the mother's father and uncle had both died of it. She remains in excellent health.

Dr. E. O. Shakespeare (*Med. News*, March 26th, 1892) attributes one-fifth of all deaths in infants and young children, feeding on milk, to tuberculosis usually commencing in some part of the digestive organs.

Identity of tuberculosis in cattle and man.—This is abundantly proved in the above instances of the infection of man through the milk and in the hundreds of cases in which the tubercle of

man has been successfully inoculated on the lower animals. As evidence of direct transference of the disease from cattle to man by inoculation the following two cases are quoted :

Tscherming, of Copenhagen, attended a veterinarian who had cut his finger in making a post mortem examination on a tuberculosis-cow ; the wound healed, but there remained a swelling which soon ulcerated and refused to heal, so that the whole tumefied mass had to be cut out. The microscope revealed the distinct tubercular process and the presence of the characteristically staining bacilli.

Pfeiffer attended a Weimar, veterinarian of the name of Moses, 34 years old, of a good constitution, and without hereditary predisposition, who, in 1885, cut his right thumb deeply in making a post mortem examination of a tuberculous cow. The wound healed but six months later the cicatrix still remained swollen, and in the autumn of 1886 the man had pulmonary tuberculosis with bacilli in his sputa and death occurred in two and a half years after the wound. Post mortem examination revealed tuberculosis of the joint of the wounded thumb, and in the lungs extensive tubercles and vomicae.

To Tscherming's may be added the case of a young veterinary friend of the writer, who was inoculated in the hand in opening a tuberculous cow, and suffered from a tumefaction of the resulting cicatrix, with distinct tubercle bacilli. The surgical removal of the tumefaction manifestly saved the subject from a generalized tuberculosis.

II. POISONING BY PTOMAINES AND TOXINS, IN MEAT AND MILK OF TUBERCULOUS ANIMALS.

By an unaccountable oversight medical and veterinary Sanitarians alike have never, up to the present hour, looked beyond infection by the tubercle bacillus in estimating the dangers to man of tuberculosis in our flocks and herds. We find accordingly that the question kept continually before the public is that of the presence or absence of the tubercle bacillus in any food product, —meat, milk, butter or cheese—furnished by the diseased or suspected animal. The question of the presence or absence of ptomaines or other toxic elements which are calculated to prove

hurtful or even fatal to certain members of the human race is not for a moment considered.

Hence we are met by the most elaborate arguments that tubercle is rare in the muscular system of cattle, and that muscle juice is inimical to the bacillus and that therefore the muscular tissue which forms the great mass of the dressed carcass may, as a rule, be safely eaten even though the internal organs may have been affected by tubercle. In Germany and other European countries the flesh of animals in which the tubercles are found in only one organ or in two related ones, is passed as wholesome. It is only when the tubercles are found in the bones, or muscles, or in the lymphatic glands among these, or finally when the tubercles are so generally distributed in different parts of the body that it is evident that the bacilli must have been carried by the blood, that the meat is rejected as unfit for human food. So with milk and other dairy products; many claim with Nocard and Mc Fadyean that the milk is harmless so long as the udder is quite free from tubercle, and that it is only when tubercle is unmistakably present in that gland that this secretion is to be feared. Apart altogether from these discussions as to the wholesomeness of uncooked flesh and milk it is safe to say that up to the present, every writer on the subject holds that even the infecting tuberculous meat and milk is rendered absolutely harmless by cooking. The consensus of professional opinion on this subject is tersely given by Salmon and Smith in their article on tuberculosis in the work on the "Diseases of Cattle" published by the Bureau of Animal Industry—"Fortunately tubercle bacilli are readily destroyed by the temperature of boiling water, and hence both meat and milk are made entirely safe, the former by the various processes of cooking; the latter by boiling for a few minutes."

But this is altogether too narrow a view to take of the subject, and it is liable to lead to most serious and fatal results if put into every-day practice. The professional mind, in concentrating its attention on *tubercular infection*, has practically entirely overlooked the no less real and, in many cases, no less dangerous fact of *tubercular poisoning*. To elucidate this matter let us consider that much of the poisonous matter produced by the growth of the tubercle bacillus is retained in Koch's "tuberculin," which has been absolutely sterilized. What, then, is the action of "tuber-

culin" on the animal system? It produces a constitutional disorder with elevation of the body temperature, commonly known as fever, and an impairment of most of the bodily functions, notably those of assimilation and secretion. This is abundantly manifest in the wasting and fever of the victim of acute tuberculosis in which these poisonous principles are being constantly produced in large quantities. As the dose is reduced, a point is finally reached at which no fever nor appreciable systematic derangement is produced, and thus in many slight and indolent cases of tuberculosis the animal appears well, and thus, also, the usual test dose of tuberculin has no recognizable disturbing effect on the healthy animal system. With a dose less than this it may even be questioned whether it may not be actually beneficial in conferring on the healthy system a small measure of tolerance and power of resistance to the bacillus and its poisons. This, however, is of little account, seeing that no real immunity from tuberculosis is ever acquired. In many systems, both human and brute, the disease continues its slow progress for many years, and the slight tolerance that results, while it may suppress the disease so that it assumes an indolent and chronic form, does not fully arrest it.

Very different is the effect of even a minimum dose of tuberculin on a subject which is already attacked with tuberculosis. In such a case the products of the existing tubercle, circulating in the blood and tissues, are often so small in amount and the system has acquired such a tolerance of them that there is no manifest disturbance of health and the animal may even be in excellent condition. But add to this minimum amount of poison already in the system a small quantity of tuberculin and in ten or fifteen hours the temperature of the patient's body will rise two or more degrees above the normal, and the destructive process going on in the seats of the tubercles will be accelerated. In cattle this is now used as a most valuable test of the presence or absence of occult tubercle. In horses and other animals, the subjects of tuberculosis, "tuberculin" causes the same rise of temperature, and this rise may be accepted as a rule applicable to all classes of animals. In the tuberculous man this action of "tuberculin" is a well established fact, and was made the basis of Koch's employ-

ment of this material as a curative agent. The daily use of tuberculin in cases of lupus or other superficial forms of tuberculosis led to a more active congestion and an earlier molecular death of the tissues of the local tubercle, until these were separated from the living, healthy parts and the progress of tuberculosis in that part was arrested. If there were then no deeper unseen tubercles left in the system, a real cure might be effected in this way. But the cure in such a case was only secured by a temporary aggravation of the disease in its primary focus. If other tubercles existed in internal organs they, too, had the morbid process aggravated and extended and the death of tissue increased by the fresh introduction of tuberculin from without. In such a case the increased mass of tubercle—dead and living—remained confined in the midst of the surrounding tissues, and as the infecting materials could not be cast off and separated from the body, they continued their ravages with an increasing force in proportion to their recent artificial extension.

It is this extension of the tuberculosis under the influence of the toxic products of the bacillus which raises the most important question in connection with the consumption by man of the flesh and dairy products of tuberculous animals and yet this question has been overlooked by sanitarians in the most unaccountable way. It has seemed enough for them that the living tubercle bacillus did not exist in the juices of the muscles nor in the milk. It seems never to have occurred to them that all the soluble poisonous products of this bacillus were constantly circulating in the blood which passes through the muscles, and that they equally traversed the blood vessels of the mammary glands and escaped into the milk. No pathologist can for a moment doubt this general diffusion of these products in the tuberculous subject.

Accepting then as undeniable the presence of the soluble chemical poisons in blood, flesh and milk, it follows that those who eat this flesh or milk are continually taking in small doses of tuberculin, and that in case they are already the victims of tuberculosis in however slight or indolent a form, this continuous accession of the poison will rouse the morbid process into greater activity and secure a dangerous extension.

If we now consider the frightful prevalence of tuberculosis in the human race, that here in New York every eighth person dies of tuberculosis, that in cities like Vienna 85 per cent. of the people suffer from it, and that in our own cities 30 to 50 per cent. contract it at some period of life, we see what a fearful risk is being run by the utilization of the meat and milk of animals so affected, even if it could be shown that such meat and milk were in themselves free from the living bacillus. Such reckless consumption of the products of tuberculous animals can only be looked on as a direct means of sealing the fate of that large proportion of the community which are already slightly affected with tuberculosis.

The claim that the canning of tuberculous carcasses and the boiling or Pasteurizing of milk does away with every element of danger can no longer be entertained. Sterilization is not a restoration to a non-poisonous condition; it does away with the possibility of infection, it is true, but it does not render the product innocuous.

As a matter of fact Koch's tuberculin has been sterilized by heat, but this has not by any means rendered it safe and harmless. On the contrary it invariably intensifies any existing tuberculous process and develops fever and general constitutional disorder. When tuberculin, therefore, is present in meat and milk it can only cause these to operate in the same way on subjects that have been already infected. In my experience with tuberculous cows, cases have come to my knowledge in which invalids drinking the milk of such animals have suffered very obviously and have improved after such milk was withheld. So too in the case of calves sucking phthisical cows; they have done badly and proved unthrifty though they took the whole of the milk furnished by their respective nurses, and they have thriven better when weaned and put upon solid food alone. I have followed some such calves until they grew up and were slaughtered, and have made post-mortem examinations and found them bearing old calcified tubercles pointing back to the time when they sucked the infected and poisonous milk.

It is idle to say that such milk was merely lacking in nutritive principles:—the calves in question had access to other food, while

following their nurses, and would not have been harmed by taking the same amount of pure water as they took of milk. Apart from the bacilli, which operated slowly, and which allowed these animals to live for years and even thrive after they had ceased taking the milk, there was unquestionably in this secretion a definite poison which undermined the health and stimulated the progress of the tuberculous process. Accessions of bacilli are not denied, but at the worst these acted tardily, and apart from the soluble poisons their action must have been cumulative up to the cessation of the milk feeding, so that immediately after the withdrawal of the milk the morbid action should have been greater than at any time before this, whereas in the cases in question improvement dated from the change to dry coarse food.

K. Yamagiva in his experiments on guineapigs obtained corresponding results. After inoculation with tubercle, the administration of tuberculin greatly hastened the onset of general tuberculosis so that after a week tuberculous centres were found in lymphatic glands, spleen, liver and lungs.

If this is the result in guineapigs which though very subject to tuberculosis are not easily poisoned by tuberculin, how much more so in man who is many thousand times more susceptible to tuberculin? The healthy guineapig is almost unaffected by 2 grammes of tuberculin, while man weighing eighty times as much is seriously affected by $\frac{1}{10}$ gramme. In the tuberculous condition the guineapig reacts violently under $\frac{1}{4}$ gramme, while man is seriously affected by $\frac{1}{1000}$ gramme. Weight for weight being considered it follows that the consumptive man is 20,000 times more susceptible to the tuberculin poisons than is the guineapig. From this may be inferred the danger to the tuberculous man, of meat or milk containing the poisons of tuberculin.

It may be safely held as proved, by analogy, observation and experiment that the soluble poisons of tuberculosis invariably operate by exaggerating any existing tuberculous process, and that blood and all animal fluids becoming charged with such poisons uniformly tend to further endanger the health or even the life of any person who may consume them while suffering from tuberculosis.

We may freely allow that the transmission of the bacillus from

man to man is far more common than from beast to man. But though the implanted seed may have been in many cases derived from a fellowman, its subsequent destructive progress may be due far more to the constant accessions of the soluble poisonous products conveyed in the meat and milk of tuberculous animals. Without these constant doses of soluble poisons of tubercle, the implanted germ would in many cases have proved comparatively harmless. Although it could be proved in regard to many cases that the cow had not contributed the seed of the diseases, she is left little less responsible for the destructive progress and fatal result. The germ which might have remained comparatively dormant and harmless in the absence of the poisoned meat and milk is by these stimulated to a more deadly energy.

HOW TO MEET THE DANGER.

This hitherto unchallenged factor in the progress of tuberculosis, opens up new and uncultivated fields for sanitary work. The great evil ventilated in this paper cannot be effectually met without the eradication of tuberculosis from every herd kept for the supply of food products for the public. Nothing short of this can be trusted to act satisfactorily in putting a check upon the present fearful mortality from this disease. No inspection of dressed carcasses, nor of milk, butter and cheese will furnish a guarantee. We must go to the herds and subject them animal by animal to a critical test, and only accept the products as safe when there is no longer a shadow of suspicion remaining. A professional examination of the most searching kind must be supplemented by the "tuberculin" test before a clean bill of health can be furnished. In my own experience on cattle two thirds of the cases of tuberculosis sometimes escaped under the most critical professional examination and were detected later by the "tuberculin" test. Often, when cattle were condemned by the "tuberculin" test, have the owners pronounced them the most thrifty and the least suspected in the herd, and it was only after slaughter, when the bodies were opened and the caseated tubercle exposed, that they were satisfied that no mistake had been made. Recently in a herd kept for the supply of high priced milk of guaranteed soundness, the stock having been subjected to weekly

examinations by a veterinarian, the "tuberculin" test was applied and 50 per cent. of the herd demonstrated to be tuberculous. Without the "tuberculin" test there is no guarantee possible for the products of the dairy, and the sanitary officers who will affect to deal with this disease in herds without the aid of "tuberculin" are at best but pruning the tips of the branches of the evil tree. Public money ought not to be thrown away on such fruitless and ineffective work. The purification of a herd must be followed in every case by a thorough disinfection of contaminated buildings and places, and by a careful seclusion of the herd from new sources of infection. It is evident therefore that the nontuberculous herd must be secured against the addition of fresh animals from any herd that has not been similarly attested sound, and that any necessary addition from another source must be tested by "tuberculin" before it is added to the herd. Equally important is it to test all farm animals of whatever species which live on the place and cohabit with the herd, and to see to it that no human being suffering from tuberculosis is allowed to attend to the animals or to prepare their food. It is difficult to see how anything short of such a system can afford a guarantee of the absence of the soluble tubercle poisons from our milk, butter and cheese.

In the case of butcher meats a professional examination when slaughtered, covering all of the viscera as well as the carcass, will be essential, and the current doctrine of sound meat with localized tuberculosis must be abandoned. Every municipality must have its own public abattoir in which alone its meat supplies should be butchered and where every carcass should be systematically examined as it is opened. Private slaughter-houses controlled by individual owners afford endless opportunities for the evasion of sanitary statutes, and ought to be abandoned as relics of an age when modern sanitary science was unknown.

The question of dressed, canned and salted meats is one that must be carefully considered. It is quite evident that such products must come to us with a sufficient guarantee if allowed to compete with our home meats which have passed the municipal inspection. It is equally evident that no inspector paid by the packer or canner can furnish a certificate which will command public confidence. The inspector must be a government official who

is entirely independent of the packers and who is in no way dependent on their good will.

Then again the existing method of furnishing government inspectors at our great packing centers only, and thus giving a monopoly to the large operators, cannot be long maintained in a country of equal rights and privileges. The most obvious cure for this evil is to make all packing establishments government institutions, where the small packer shall have equal privileges with the large, and where all carcasses shall be subjected to the same scrutiny and all shall go out with the same guarantee.

Such a proposition will doubtless be severely criticized both from the medical and economic standpoint.

On the medical side it will be argued that if the soluble poisons in the meat and milk were as injurious as represented, we would see the evil results on every side and that medical men would be universally cognisant of them. And yet do we not see clearly to-day much that was never suspected twenty, thirty or fifty years ago? How recent is the acceptance by the profession of the doctrine of contagion in tuberculosis, in tetanus, in pneumonia, in influenza, in glanders, etc. Are we to suppose that our forefathers were surrounded by fewer evidences of contagion, at a time when no precautions were taken to prevent it, than we are with all the antiseptic and antizymotic provisions of the present day? The facts of contagion were doubtless more abundant in their days than in these, but their attention had never been drawn to them. So now let the attention of physicians and sanitarians be given to the morbid action of soluble poisons of tubercle and evidences of their evil results will accumulate on all sides. It is the scrutiny and not the facts that are wanting.

The economist will object to drastic measures for the suppression of tuberculosis on the ground of expense. Who is to pay for the municipal abattoirs, the inspectorships, the disinfections, and the indemnities for slaughtered animals? In return let me ask, who now pays for the constant losses of live stock which the proposed system would put a stop to; for the frequent infection of sound herds by unfortunate purchases of animals that prove to be tuberculous; for the losses to the nation, to the community and family of the tuberculous one-eighth of all deaths; for the loss of

work—literary, scientific, manufacturing, commercial, domestic and manual of the great host of consumptives waiting all over the land to fill the places of this fatal eighth in coming mortality statistics ; for the losses represented by the bills of the physician, nurse and druggist for these invalids ; and for the losses represented by the many migrations and exiles in search of health and of the costly consumption hospitals and sanatoria ? And who is to pay in the future for the needless harvest of similar fruits, which the seeds now sown through our supineness, must inevitably produce in the coming generations ?

Is it not a truer economy to destroy the seed before it has germinated, or even before it has been sown, than to wait for the multitudinous evils that must attend on its growth and fructification ?

PREVENTIVE MEASURES FOR ADOPTION BY THE STOCKOWNER.

If he will the stockowner can extirpate this disease from his herd and thereafter keep the herd pure from such contamination. The following are the main precautions necessary to this end :

1st. Board up the partitions of the stalls at the front so that no two cows can feed from the same manger nor lick each other.

2d. Keep each animal strictly by its own stall and manger.

3d. When any animal is suspected don't let it use a drinking trough nor bucket in common with other animals.

4th. Avoid old milch cows and unthrifty ones, or keep them secluded from the rest of the herd.

5th. The following conformation usually indicates a weakness of constitution and a susceptibility to tuberculosis : Head narrow between the horns, sunken eyes, depth of cavity (temporal) back of the eyes, thin narrow ewe neck, chest small, lacking in both breadth and depth, hollow flank and tendency to pot belly, a general lack of muscle so that the limbs seem loosely attached to the body, in breeds that show a variety of colors, animals of the lighter shades of brown and yellow. If, however, such animals are of high value for the dairy, and can be kept free from infection they need not be rejected. The finest conformations of shorthorns, Devons, Holsteins, black or red polled furnish no protection in the presence of the germ.

6th. Don't purchase from a herd in which tuberculosis has appeared or in which cattle have died or been killed within a year or two. Resort first to the tuberculin test.

7th. Don't take a cow with a husky or rattling cough, wheezing, hurried breathing, discharge from nose, foetid breath, hard bunches under the skin, diseased udder, swollen bones or joints, unthriftiness, or a tendency to scour or bloat.

8th. Don't purchase from city, suburban nor swill stables.

9th. Don't add newly purchased cattle to your herd until you have tested them with tuberculin, especially if they have been the product of inbreeding.

10th. Don't admit strange cattle to house, field nor yard with your own; keep them apart until tested with tuberculin.

11th. In case of disease or unthriftiness in your herd put the animal apart and have it examined by a skillful veterinarian.

12th. If after this there remains any doubt as to the real nature of the disease, have the animal tested with the tuberculin, in the hands of a practitioner thoroughly acquainted with cattle and their diseases. If the result is not yet quite clear keep the animal by itself and repeat the test in four weeks.

13th. In case one animal in a herd shows tuberculosis test the whole herd with tuberculin.

14th. Test in the same manner all animals on the farm (swine, goats, sheep, horses, rabbits, cats, dogs, fowls) that cohabit with the cattle.

15th. Kill all tuberculous animals and boil, burn, dissolve in acid, or bury deeply in a place to which no animals have access.

16th. Disinfect premises thoroughly, also all products of the diseased animals and all articles used about them.

17th. Let no consumptive person attend on cattle or other live stock, nor prepare their food.

18th. Vermin (rats, mice, sparrows) in a building where tuberculous animals have been, should be exterminated.

STATE MEASURES FOR THE PREVENTION AND EXTINCTION OF TUBERCULOSIS IN FARM ANIMALS.

The best, most effective, and economical measures for the suppression of tuberculosis are those which naturally devolved on

the State. It does not follow, however, that State interference will exonerate the stockowner from his personal duty in taking the precautions laid down for him above. It is the duty of the State to see that all such precautions are enforced, together with others that transcend the power of the individual stockowner, and must be undertaken by the governing power for the public good. Among these may be named the following :

1st. The providing of municipal slaughter houses in which alone farm animals designed for human food can be slaughtered.

2d. Exclusion from the home market of all dressed, salted and canned meats, that have not passed a crucial examination at the time of slaughter by an accomplished government veterinary inspector.

3d. Government stamping and labelling of all canned meats that have passed the municipal inspection and can be guaranteed as from nontubercular animals.

4th. Forbid the use for pigs, fowls or other animals of all milk furnished by tuberculous animals, and of all offal or other products of slaughter-houses until they shall have been boiled for one hour.

5th. Provide for the systematic inspection by skilled and reliable veterinary practitioners, of all dairy herds and primarily of such as furnish milk for immediate use as sweet milk.

6th. If tuberculous cattle or other animals are found in a herd, have the remainder tested with tuberculin, and have all affected cattle appraised, killed, and, without delay or further expense, paid for by the State.

7th. Appraisers may be chosen one for the State and one for the owner, or better, to secure a more even handed justice, all alike should be valued by two State appraisers chosen for their knowledge of animals and their values, and for their integrity.

8th. Indemnities should be paid without delay on presentation of the affidavits of the stockowner, the inspector and the State appraisers.

9th. The precautions prescribed for private owners under the headings 9 to 15, and 18 should be carried out under the supervision of State officers.

10th. Disinfection of all contaminated premises and objects

should be done at State expense and by a special disinfecting corps under a trained, careful and thorough foreman.

11th. Attendants on cattle or other meat producing animals, who show any chronic disease of the air passages, lungs or bowels, should be examined for tuberculosis, by the municipal or town health officer, and their expectoration should be tested bacteriologically. If found to be tuberculous they must be forbidden to continue this occupation.

12th. Though herds have been tested and guaranteed sound, such guarantee must lapse as soon as new animals are introduced into them from public markets or untested herds. The guarantee may be preserved by having all such additions tested by tuberculin before they are added to the herd.

13th. In making tests with tuberculin the inspector will, as a rule, omit cases that are suffering acutely from other diseases or from advanced general tuberculosis, or that are approaching *oestrus* or parturition, such cases must be secluded and tested later when there is no such source of fallacy.

14th. All deaths in inspected and attested herds should be promptly reported to the government veterinary inspector of the district, who should make a careful post mortem examination and if he finds tuberculosis in even a latent form, the whole herd should be again tested with tuberculin.

DEFECTS OF THE EXISTING NEW YORK LAW.

New York is to be highly commended for taking an advanced position in the suppression of tuberculosis by process of law. It is to be regretted, however, that excellent intentions have been somewhat marred from a lack of acquaintance with the diseases of the lower animals, by those who have drawn and those who directed the administration of the law. It may not be altogether useless to name some of the more obvious defects in the law as hitherto in force.

A. THE PROVISION FOR TWO SEPARATE VETERINARY SANITARY BOARDS.

By existing law tuberculosis and glanders are dealt with by the State Board of Health, while all other diseases affecting the same

genera of animals are placed under the supervision of the Commissioner of Agriculture. The inspector under both central authorities ought to be a veterinary comparative pathologist acquainted with the whole range of animal diseases in order to deal with one—say tuberculosis—to the exclusion of other affections, and yet when he meets with another contagious disease he is helpless to do anything in the matter, and so are his superiors; application must be made to another department, which must send its own inspectors, though an entirely capable government employe is already on the ground, and an entirely new set of machinery must be set in motion to accomplish what could have been done far more promptly, effectively and cheaply by the inspector and bureau which were already in the field. Two bureaus with their officers and records are delegated to do work which naturally belongs in one, and delay, inefficiency and unnecessary outlay can be the only results of such an extraordinary distribution of functions.

B. DELAY IN KILLING THE DISEASED.

When an animal is condemned as tuberculous, it is not in the power of the inspector to at once suppress the danger, by seeing to the destruction of the beast; he must report to his superior in Albany and receive his order before he can go a step farther. The enforced delay hinders him from attending to other cases promptly and greatly enhances the cost of the work. By employing trustworthy inspectors only, allowing them to dispose of the sick and dangerous at once, and having their reports checked by the affidavits of the owners and appraisers, the work can be rendered far more effective and economical.

C. NO PROVISION FOR APPROVED APPRAISERS.

The law says the condemned animals shall be appraised, but fails to say how, and in the past the owner of the stock had to choose his own appraisers and the claims based on such appraisements naturally came up for liquidation under a cloud of discredit as having been made by men acting in the interest of the stockowner. No wonder that in some cases the loser of a tuberculous animal

found that the cost of establishing his claim amounted to more than the claim was worth. Two appraisers mutually chosen for State and stockowner, or still better, two honorable State appraisers who shall make affidavit to each estimate of value will do evermore and more substantial justice to the owner of the stock, and the appraisement will come up for liquidation without the suspicion that attaches to such documents under the present system. If these are judiciously selected for skill and integrity, their awards, backed by the affidavits of the owner and inspector, will come to the disbursing officer with the best possible guarantee of their justice.

D. REFERENCE TO THE COURT OF CLAIMS.

By the present law every award for animals killed must be considered and allowed by the Court of Claims. The object is to secure justice, but it is manifest that the precaution begins too late. The Act leaves the owner to select his own appraisers, and unscrupulous persons may conspire to secure an excessive award in spite of the best efforts of the Court, who have never seen the animals valued, and can only act on the evidence furnished. The way is open therefore, for the unprincipled to prey on the State, while the man of principle correspondingly suffers. The remedy is to have appraisers, state officers and trustworthy men, in which case their decision will be at once more intelligent, fair, and equitable, than any revision that can possibly be made by a court sitting at a distance, however able and honorable its judges may be.

E. DELAY IN PAYING INDEMNITIES.

As a necessary consequence of the reference to the Court of Claims, much time is lost in preparing the case and in waiting the turn of the particular entry on the list. As a rule hearings have been had from nine to twelve months after the slaughter of the animals. This is no real advantage to the State which is saddled with the attendant Court expenses. It is often a serious matter to the stockowner, who is thus kept out of his source of livelihood, or has to borrow and pay interest on the money-value of the animals killed. Knowing the consequences of such delay, and that in

addition to this they must expend considerable money in preparing and presenting their claims before the Court, and in furnishing witnesses, many prefer to make no report of the disease to the authorities but to deal with it themselves. If men of high principle they personally bear all the losses, but if not, they too often send the diseased animals to market and thus provide for the starting of new centres of infection, or they slaughter them and sell the carcasses as human food. Thus the system of indemnification, surrounded, as it is by delays and uncertainties, becomes a means of spreading instead of restricting or extirpating the affection.

With the obvious safeguards of the affidavits of worthy men acting as inspectors and appraisers, for the State, and with the endorsement of their superior officer, payments could be made promptly, and the dread of serious loss would no longer deter stockowners from coöperating heartily with the State in the purifying of their herds. Relieve the owner of the present vexations delays, of the legal and court expenses and the State will be furnished with a powerful lever for the work of suppressing the contagion.

F. NO PROVISION FOR EFFICIENT DISINFECTION.

The existing law provides no definite means for the disinfection of contaminated premises, and, therefore, this most essential duty is thrown upon the owner to accomplish at his own expense and too often in his own way. Yet the extreme measure of killing the infecting or diseased animal entails the imperative duty of thoroughly disinfecting the place where such animal has been. Without this the expropriation and killing is a comparatively futile procedure. In the hands of an inexperienced farmer the attempt at disinfection is far more likely to be insufficient than complete, and if imperfect all or much of the trouble and expense has been thrown away. In all veterinary sanitary work looking toward the extinction of a contagion, the work must be of a very radical nature, and if it fails in this it may be looked on as practically a failure. Restriction of the disease there may be without this, but extinction, never. With mere restriction outlay for pre-

vention must go on forever; with extinction it will be brought to a final end.

To be effective, disinfection should be made the work of trained state officials. There is no more reason why this should be charged on the stock owner than that he should bear alone the money loss of his animals. Both are means of the extinction of the contagion with the one object of the public good.

G. NO PROVISION FOR SYSTEMATIC WORK.

The existing law fails to provide means for dealing with tuberculosis in all parts of the state, or to enjoin that the limited means provided shall be applied in a systematic manner upon any given area. Attention is therefore given to the herds whose owners make special application for inspection and those that are reported by others, and thus the inspectors are to-day in Westchester county, to-morrow in Erie, and the next in Tioga or Oswego. Single reported herds are dealt with and the great bulk of stock in the same district are passed over unnoticed. Is it to be wondered that complaints of partiality are heard? With the utterly inadequate appropriation this condition of things is perhaps inevitable, but it is certainly not the way to suppress the disease. A system that wipes out the disease on one farm, and at once leaves it to be reinfected, from a diseased herd on the next place perhaps, is anything but commendable. If the means can be afforded to deal with the disease over the entire state, let this be done; but if not then let the appropriation be applied to a given geographical district and let this be purified as a whole and held so, while the good work is extended to other regions.

INSUFFICIENT INDEMNITY A FALSE ECONOMY.

In conclusion, it is right to emphasize the importance of a due consideration of property rights. Sanitary laws which in any way ignore or disregard the rights of property have within themselves the seeds of defeat. If within our municipal abattoir the butcher cannot conduct his business as well and economically as in his own establishment, he or his competitors will evade the law in some way. If the stock owner is not fairly reimbursed for

his animals slaughtered and for other losses sustained for the protection of the public health and of the country's herds, unscrupulous men will find ample means of trading off the as yet incipient and occult cases of tuberculosis, and thereby planting the infection widely in new herds. Compensation must stop short of making the sanitary bureau a profitable customer for tuberculous animals at sound prices, but it must be so liberal as to enlist the ready coöperation of the stock owner in having every infected beast safely disposed of. Cases of advanced generalized tuberculosis may in all justice be listed at a low rate, as they are in every sense unfit to live, and are an expense, a danger and a nuisance even when dead. Cases too that have just been imported from another state or country and which are either manifestly diseased or taken from a tuberculous herd may fairly be excluded from indemnity and above all from a liberal indemnity. But in nearly every herd the majority of the stock condemned are to all outward appearances sound animals, and the owner has had no suspicion concerning them until this has been betrayed by the tuberculin test. But for that he would have gone on utilizing the animals in perfect good faith, and his customers would have received the dairy products in all confidence as to their wholesomeness. Had he wished to sell these animals for the dairy or for beef, he would have found plenty of purchasers at sound market rates. If the stock were thoroughbred and their progeny of a high prospective value he could have continued to breed from them for years since calves are rarely born tuberculous—not once in many thousand births even from tuberculous parents—and thus he might have largely profited by raising them on the milk of healthy cows. Then again in country districts the owner must bear the cost of disposing of the carcass by burning or burial in some place to which other animals do not have access. Further, the essential work of disinfecting the premises is at present put on the shoulders of the stockowner. Once more, if the stockowner is a dairyman, his trade is injured by the condemnation of animals in his herd. Customers will suddenly change to other dairies, creameries will be closed against his milk, and health officers are likely to quarantine the product, at least between the condemnation and slaughter. Apart from this his home supply

of milk is lessened and to keep his customers he must go into the market and buy milk from others.

It is quite evident that in many cases of dairy herds and of valuable thoroughbred animals, an indemnity amounting to even the sound market value of the animals killed comes far short of reimbursing the owner for his actual losses.

These considerations should be taken fully into account, before adopting any proposal to fix a maximum sum or rigid rule for estimating values. The wording of the present law "the actual value" is perhaps as good as any, only provision should be made to have able and incorruptible appraisers, and a restricting clause might be introduced to prohibit or minimize awards for animals recently introduced into the State.

Disinfection should as a rule be done by State employes, thus relieving the stockowner of the expense and securing effective results. The disposal of carcasses may also in many cases be justly charged on the State. This cannot be an entering wedge for corruption, as excessive indemnity would be, and yet it would relieve the stockowners of an outlay that should be met by the public at large.

The disposal of infected manure and other products must be under the direction of the inspector, but must evidently be undertaken by the stockowner himself.

Points like the above cannot be too strongly insisted on, as they determine success or failure. In the extinction of cattle lung-plague in the United States the strict attention to such accessories proved the main factors in the speedy success. In Cook Co., Ill., I took charge of the work on behalf of the United States Government in April, 1887, and in July we had done away with the last acute case of the disease. But the whole city was systematically purged, stable by stable, no communication between sick and healthy was possible, condemned cattle were quickly disposed of, and in two weeks each owner received from Washington a check for the amount of his indemnity; thorough disinfection was effected by a government corps so that no stable ever needed to be disinfected a second time, and effective measures were taken to prevent the introduction of new cattle from infected localities. No state was ever so speedily cleared of this

disease and the result must be altogether attributed to the carefulness of the methods, and their thorough application, and not least to fair indemnities and the promptitude of their payment. Great Britain has been struggling with the same disease for fifty years, and though she slaughters the sick, yet for lack of other efficient measures she cannot yet show a clean bill of health.

50.679

N7

282b

Bulletin 66.

May, 1894.

Cornell University Agricultural Experiment Station.

AGRICULTURAL DIVISION.

TEST OF CREAM SEPARATORS.



— BY —

HENRY H. WING.

PUBLISHED BY THE UNIVERSITY.

ITHACA, N. Y.

1894.

ORGANIZATION.

BOARD OF CONTROL: THE TRUSTEES OF THE UNIVERSITY.

STATION COUNCIL.

President, JACOB GOULD SCHURMAN.

HON. A. D. WHITE,	-	-	-	-	Trustee of the University.
HON. JOHN B. DUTCHER,	-	-	-	-	President State Agricultural Society.
I. P. ROBERTS,	-	-	-	-	Professor of Agriculture.
G. C. CALDWELL,	-	-	-	-	Professor of Chemistry.
JAMES LAW,	-	-	-	-	Professor of Veterinary Science.
A. N. PRENTISS,	-	-	-	-	Professor of Botany.
J. H. COMSTOCK,	-	-	-	-	Professor of Entomology.
L. H. BAILEY,	-	-	-	-	Professor of Horticulture.
H. H. WING,	-	-	-	-	Asst. Professor of Dairy Husbandry.
G. F. ATKINSON,	-	-	-	-	Asst. Professor of Cryptogamic Botany.

OFFICERS OF THE STATION.

I. P. ROBERTS,	-	-	-	-	Director.
HENRY H. WING,	-	-	-	-	Deputy Director and Secretary.
E. L. WILLIAMS,	-	-	-	-	Treasurer.

ASSISTANTS.

M. V. SLINGERLAND,	-	-	-	-	Entomology.
GEO. C. WATSON,	-	-	-	-	Agriculture.
G. W. CAVANAUGH,	-	-	-	-	Chemistry.
E. G. LODEMAN,	-	-	-	-	Horticulture.

Offices of the Director and Deputy Director, 20 Morrill Hall.

Those desiring this Bulletin sent to friends will please send us the names of the parties.

BULLETINS OF 1894.

62. The Japanese Plums in North America.
63. Co-operative Test of Sugar Beets.
64. On Certain Grass-Eating Insects.
65. Tuberculosis in Relation to Animal Industry and Public Health.
66. Test of Cream Separators.

TEST OF CREAM SEPARATORS.

During the session of our Short Dairy Course for 1894, there were in operation seven different styles and sizes of centrifugal cream separators ; this gave us a favorable opportunity for making a careful study of the efficiency of the different sizes and styles. These separators, a list of which is given below, formed a part of the equipment of the Dairy Building, the use of several of them as indicated below, being donated to the University by the several makers.

The various sizes and styles were as follows :

1. *Sharples' Standard Russian* ; donated by the manufacturer, P. M. Sharples, Westchester, Penna.
2. *The Victoria* ; manufactured by Watson, Laidlaw & Co., of Glasgow, Scotland, the Dairymen's Supply Co., Philadelphia, Penna., agents for the United States.
3. *De Laval Alpha No. 1* ; donated by the manufacturers, the De Laval Separator Co., 74 Cortlandt St., New York City.
4. *De Laval Baby No. 3* ; manufactured by the De Laval Separator Co., 74 Cortlandt St., New York City.
5. *Columbia No. 1* ; donated by the manufacturers, the Columbia Separator Co., Avon, N. Y.
6. *The Butter Accumulator* ; donated by the manufacturers, The Swedish Cream and Butter Separator Co., Bainbridge, N. Y.
7. *The United States Extractor Separator No. 3* ; manufactured by the Vermont Farm Machine Co., Bellows Falls, Vt.

The separators, as shown in the accompanying cut, were mounted on solid stone piers and each was driven by a separate counter shaft which in turn received its power from the main shaft running through the building. The power was furnished by a 25 horse power Westinghouse engine which furnished ample power to run all the separators at once and maintain the main shaft at a very

uniform speed. The conditions of power and speed were as favorable for all of the machines as it was possible to make them. The single turbine machine, the Sharples' Standard Russian, received the steam at a boiler pressure of from 60-80 pounds per square inch which was reduced to 40 pounds before entering the turbine.

The machines were run by the students in the Dairy Course, under the direct supervision of Mr. Dewitt Goodrich, the instructor in butter making, each student working in turn upon each machine. None of the tests here reported were made until after the school had been in session for four weeks, and the students had attained considerable skill in handling the separators. The school closed on March 21st and the tests that were made after that date were all made by one person, Mr. W. D. Saunders, a man thoroughly familiar with the handling of separators. Several runs were made by him from each separator, with the exception of the De Laval Alpha No. 1 which was returned immediately after the close of the school. It will be seen that the runs made by Mr. Saunders agreed in their results very closely with those made during the session of the school.

The measure of the efficiency of a cream separator is the amount of fat left in the skim milk, but all of the separators left only small amounts and in order to make the tests as accurate as possible the determination of fat in the skim milk was made by the absolute gravimetric method by the Assistant Chemist of the station, Mr. G. W. Cavanaugh. Where skim milk contains only .1 or .2 per cent. of fat, it is so difficult to read the amount upon the neck of the test bottle that we have entirely abandoned the use of the Babcock Test in work of this sort where it is necessary to distinguish slight differences. The Babcock Test is no less useful in checking the work of separators, for the creamery man should run his separator so that only a scarcely perceptible amount of fat appears in the neck of the test bottle. It is a common thing in testing skim milk with a Babcock tester, to find so small an amount of fat that it will not reach clear across the neck of the test bottle but will adhere to one side in the form of a small drop. It is not uncommon to find such tests reported as ".05 per cent.," ".01 per cent.," "mere trace," "globule size of a pin head, etc." We have found in a large number of such tests that

the gravimetric analysis will show between .1 and .15 of 1 per cent. of fat in the skim milk.

The samples of skim milk were taken in all cases from the mixed skim milk of the entire run, and not caught directly from the skim milk outlet of the machine at any period of the run.

The runs were short particularly for the larger capacity machines and in making short runs the error in computing the capacity per hour is largely increased for the reason that unavoidably part of the milk at the last end runs through slower, so that in interpreting the tables a certain allowance should be made in the capacity per hour, particularly for the Alpha No. 1 and the Sharples' machines.

The milk used was, in all of the tests between January 30th and March 23d inclusive, the milk furnished to the Dairy School by farmers. This milk was not always in the best condition for handling. The milk of the evening and following morning was shipped together about twenty miles by rail, and reached the Dairy Building in the afternoon and was not worked up until the following day, so that all of it was twenty-four hours old and some thirty-six hours old before being worked. Moreover, on many occasions it was received at the Dairy Building in a frozen condition. In all of the tests made after March 24th the milk of the University herd was used and it was separated immediately after milking, so that we had in these tests milk in its most favorable and unfavorable conditions.

Mr. Goodrich, Mr. Saunders and Mr. Cavanaugh did a large part of the work here reported and much of the credit of it is due to them.

In the tables following are given the data concerning the various runs of the different machines. The tables are given in the order of the list of the machines given at the beginning of the Bulletin and any peculiarity of the running of the machines is mentioned in connection with them.

TABLE I.—SHARPLES' STANDARD RUSSIAN.

Date.	Pounds of milk used.	Length of run, min.	Pounds separated per hour.	Percent. of fat in skimmed milk.	Speed of bowl, revolutions per minute.	Per cent. of fat in whole milk.
Jan. 30.....	689	33	1253	.27	7000	4.3
Feb. 3	327	17	1154	.30	7500	3.7
" 6.....	524	30	1048	.24	7200	4.2
" 8	540	26	1246	.19	7200	4.1
" 10	340	17	1200	.21	7200	3.8
" 12.....	827	46	1080	.26	7400	3.9
" 13.....	637	34	1113	.28	7200	3.5
" 16.....	402	24	1005	.22	7400	3.7
" 20.....	880	40	1320	.49	7000	3.9
" 21.....	384	22	1047	.25	7200	3.5
" 24.....	375	20	1125	.27	7200	3.9
" 27.....	531	30	1062	.20	7000	4.1
Mch. 3.....	726	33	1320	.20	7000	3.6
" 5.....	825	40	1238	.21	7200	3.6
" 9	309	28	662	.34	7300	3.8
Apr. 6, A. M.	110	9	733	.21	7000	3.5
" 6, P. M.	186	9	1240	.48	7000	4.4
" 10, "	168	8	1260	.25	7000	4.
" 11, "	169	9	1127	.27	7000	4.
" 12, "	168	10	1008	.28	7000	4.1
Average			1112	.29		

This machine is extremely simple and easily run. Taking care that the boiler pressure was always 20 to 40 pounds above the required pressure upon the turbine we found that the speed of the bowl was very uniform. No difficulty was had in getting cream of any desired thickness and the cream came from the machine smoothly and uniformly and several degrees cooler than the milk entered.

These results show a rather large percentage of fat in the skim milk and at the request of the manufacturers we visited the factory of Fisher & Garrett, Baldwinville, N. Y., and took samples of skim milk from an Imperial Russian Separator running under factory conditions. Five samples were taken in all from five consecutive runs, two runs were made each day and the machine was taken down and cleaned between them. The samples were taken by catching a half pint from the skim milk outlet, at intervals of fifteen minutes during the run. These samples were thoroughly mixed and a sample taken for analysis. In this way a representa-

tive sample of the whole run was obtained. The results are given below :

TABLE I A. SHARPLES IMPERIAL RUSSIAN.

Date.	Pounds of milk used.	Length of run. Minutes.	Pounds separated per hour.	Per cent. of fat in skimmed milk.	Speed of bowl, revolutions per minute.
June 9, 1st	4779	150	1910	.20	7300
June 9, 2d	2649	82	1935	.25	7500
June 10, 1st	7324	145	1990	.16	7500
June 10, 2d		76		.20	7500
June 11, 1st	2642	90	1760	.18	7500
Average			1900	.20	

TABLE II—VICTORIA. 75 GALLON.

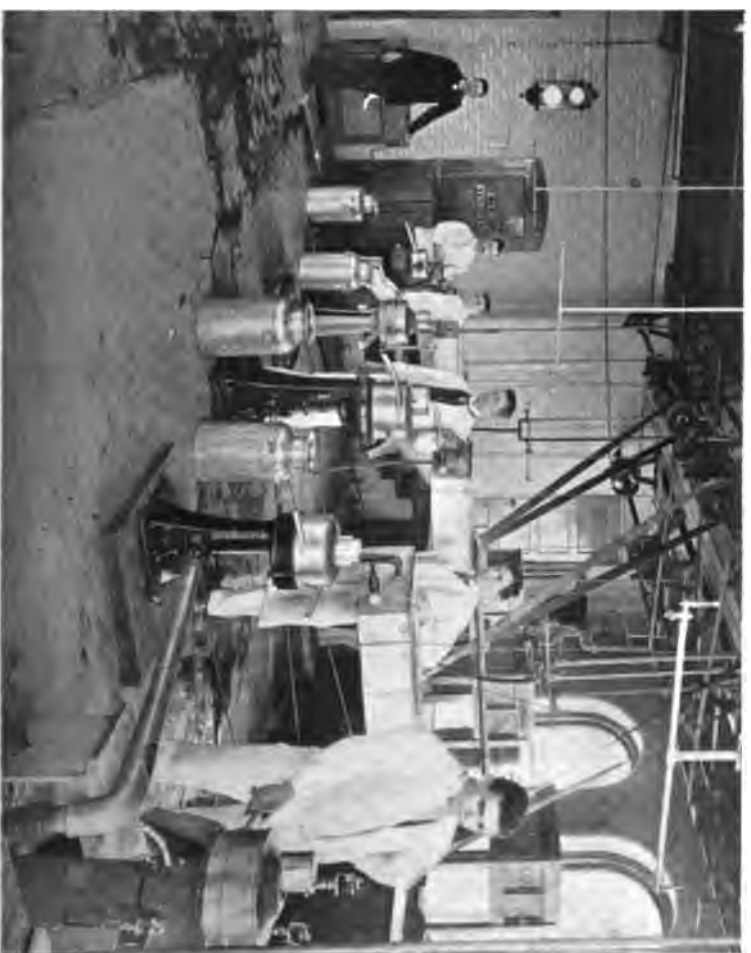
Date.	Pounds of milk.	Length of run. Minutes.	Pounds separated per hour.	Per cent. of fat in skimmed milk.	Speed of intermediate. Revolutions per minute.	Calculated speed of bowl. Revolutions per minute.	Per cent. of fat in whole milk.
Feb. 2	240	20	720	.28	1016	6175	3.4
" 15	225	26	519	.80	1000	6100	3.8
" 16	323	25	775	.19	1000	6100	3.8
" 26	444.75	38	702	.11	1060	6450	4.
" 28	413	36	688	.19	1000	6100	3.7
Mch. 1	555	40	832	.25	1000	6100	4.
" 30, P. M..	182	13	840	.14	1100	6700	4.1
Apr. 1, A. M..	471.5	38	744	.28	940	5725	3.4
" 3, P. M..	208	16.5	756	.18	1060	6450	4.2
" 4, A. M..	140	10	840	.15	1040	6325	3.5
" 4, P. M..	195	17	688	.16	1030	6275	4.4
" 5, A. M..	124	10	744	.16	1040	6325	3.4
Average			737	.19			

This machine ran with an intermediate with a leather belt and some little difficulty was found in keeping the belt tight and the speed uniform, and occasionally the cream was slightly lumpy, otherwise than this no peculiarities were noticed.

TABLE III—DE LAVAL, ALPHA NO. I.

Date.	Pounds of milk used.	Length of run. Minutes.	Pounds separated per hour.	Per cent. of fat in skimmed milk.	Speed of bowl. Revolutions per minute.	Per cent. of fat in whole milk.
Jan. 30.....	898	30	1796	.14	6000	4.4
Feb. 2.....	373	17	1316	.12	6000	3.
" 3.....	372	18	1240	.09	6000	4.2
" 6.....	458	25	1099	.07	6000	3.9
" 9.....	235	14	1007	.11	6000	4.
" 13.....	1022	35	1752	.09	6000	4.
" 15.....	358	17	1263	.05	6000	3.8
" 16.....	586	28	1255	.16	5800	3.5
" 17.....	480	15	1920	.12	6200	3.7
" 19.....	849	30	1698	.11	5900	3.8
" 26.....	639	25	1526	.08	6000	4.
" 27.....	714	25	1714	.09	6000	3.8
" 28.....	535	24	1338	.10	6000	3.8
Mar. 8.....	643	23	1677	.09	6200	3.5
Average.....			1471	.10		

It will be noticed that on scarcely any occasion was this machine run to its full capacity. This was not due to inability to get the milk through the machine but largely to the shortness of the runs. It will be noticed in referring to the table that on the occasions where 1800-1900 pounds of milk were run through, there was no more fat in the skim milk than when a less amount was run. In the four highest runs the average amount of milk separated per hour was 1800 pounds with .11 of 1 per cent. of fat in the skim milk. In the four smallest runs the amount of milk separated per hour was 1150 pounds, with also .11 of 1 per cent. of fat in the skim milk. This machine ran with an intermediate and rope belt and no difficulty was found in maintaining the speed uniformly, as was the case with the other machines operated in the same way, the Columbia and the Accumulator. The character of the cream as to density and consistency was also all that could be desired.



Installation of Separators.

TEST OF CREAM SEPARATORS.

167

TABLE IV.—DE LAVAL BABY NO. 3.

Date.	Pounds of milk used.	Length of run, min.	Pounds separated per hour.	Per cent. of fat in skimmed milk.	Revolutions of bowl per minute.	Per cent. of fat in whole milk.
Feb. 8.....	257.5	33	468	.16	5750	3.7
" 16.....	419	60	419	.22		3.7
" 26.....	257	26	593	.18	5750	3.6
Mch. 1.....	315	31	610	.14	6150	4.
" 3.....	138	15	552	.19	5500	3.8
" 27, P. M....	181	19	571	.22	5300	4.2
" 28, A. M....	113.5	11.5	592	.24	5300	3.6
" 28, P. M....	188	20	564	.21	5000	4.
" 29, A. M....	117	12	585	.21	5000	3.3
Apr. 2, P. M....	200	20.5	585	.16	5000	4.2
" 3, A. M....	152	16	570	.25	5080	3.5
" 5, P. M....	186.5	19	589	.11	5300	4.2
" 16, ".....	201	20.5	588	.12	5333	4.
" 17, A. M....	117			.12	5334	3.5
" 17, P. M....	192.5	19	608	.11	5334	4.2
" 18, A. M....	122	12	610	.12	5334	3.8
" 21, ".....	127	12	635	.12	5900	3.4
Average.....			571	1.7		

This machine, so far as condition of cream and other details of operation were concerned, was perfectly satisfactory.

TABLE V.—COLUMBIA NO. 1.

Date.	Pounds of milk used.	Length of run, min.	Pounds separated per hour.	Per cent. of fat in skimmed milk.	Speed of intermediate Rev per minute.	Calculated speed of bowl Rev. per minute.	Per cent. of fat in whole milk.	Per cent. of fat in cream.
Mch. 6.....	50	10	300	.18	1060	7700	3.6	10.
" 7.....	256	48	320	.14	1080	7850	3.5	12.
" 8, A.M....	82	15	328	.11	1100	7975	3.8	13.7
" 8, P.M....	257	45	343	.84			3.3	16.
" 9.....	120	25	288	.19	1032	7490	3.2	17.8
" 10.....	83	15	332	.21	1060	7700	3.6	18.6
" 13.....	80	15	320	.08	992	7200	3.2	9.6
" 14, A.M....	81	15	324	.10	1070	7775		18.6
" 14, P.M....				.11				
" 15, A.M....	88	17	311	.10	1070	7775	3.8	15.6
" 15, P.M....				.09				
" 16.....	80	16	300	.09	1002	7275	3.8	15.4
" 26, P.M....	177	30	354	.12	1035	7500		
" 27, A.M....	119	21	292	.12	1050	7625	3.8	11.6
" 29, P.M....	183	34	323	.12	1060	7700	4.2	12.4
" 30, A.M....	128	25	307	.11	1015	7375	3.8	13.4
Apr. 2, A.M....	359	64.5	334	.10	1030	7725	3.8	8.6
Average.....			318	.18				

The peculiarity of this machine is that the bowl is made of aluminum and is much lighter than other bowls of the same capacity. It delivered the cream in very good condition and at a temperature lower by several degrees than the milk entered, but it was not found possible to get cream of a greater fat content than 18 per cent. without materially increasing the percentage of fat in the skim milk. We are informed by the manufacturers that this difficulty has been obviated in the machines now made but we have not yet had an opportunity to make a test.

TABLE VI—BUTTER ACCUMULATOR AS SEPARATOR.

Date.	Pounds of milk used.	Length of run, minutes.	Pounds separated per hour.	Per cent. of fat in skimmed milk.	Speed of bowl Revolutions per minute.	Per cent. of fat in whole milk.	Per cent. of fat in cream.
Mar. 16.....				.10			
Apr. 7 A. M..	137.5	26	317	.09	7200		11.2
" 7 P. M..	177	27	393	.14	7200	4.4	22.2
" 8 A. M..	114	15	456	.11	7200	3	12.
" 9 A. M..	310	35	531	.11	7200	3.8	11.6
" 9 P. M..	176.5	25	424	.17	7200	4.2	
" 10 A. M..	113	16.5	411	.17	7200	3.6	
" 16 A. M..	133.5	21	381	.20	7200	3.6	
" 20.....	147			*.12	7200	3.2	
Average.....			416	.18			

* Run as a butter machine.

This machine worked perfectly satisfactorily as a separator in all respects, except that a very heavy cream could not be obtained without materially cutting down the capacity. In the tables of this machine and the Columbia we have added a column showing the per cent. of fat in the cream of the different runs. In the case of the other machines this was not thought necessary, because the fat in the cream ran uniformly between 25 per cent. and 30 per cent.

We have also used the Accumulator as a butter machine. On March 16th the representative of the company made two successful runs, turning out butter of good grain and texture with a capacity of 300 pounds of milk per hour and with a clean separation. We have not been able to obtain uniformly so good results

in texture of butter, mainly we think, because of the extremely delicate adjustment of the inflow that is necessary. We make this mention provisionally as we are still working with the machine and hope to be able to make a fuller report later on.

TABLE VII—UNITED STATES EXTRACTOR SEPARATOR NO. 3.

Date.	Pounds of milk used.	Length of run. Minutes.	Pounds separated per hour.	Per cent. of fat in skimmed milk.	Speed of bowl. Revolutions per minute.	Per cent. of fat in whole milk.
Feb. 8.....	417.5	35	715	.14	9240	3.6
" 9.	240	22	655	.15	8250	3.7
" 10.	308	22	840	.15	8200	3.6
" 12	385	34	679	.18	8000	3.6
" 14.....	352	30	704	.18	8000	3.7
" 21.....	336	31	650	.09	8200	3.8
Mch. 5.....	188	20	564	.10	8600	4.5
Apr. 13 P. M....	174	17.5	590	.11	8600	4.2
" 14 P. M....	176	18.5	570	.12	8400	4.2
" 15 A. M....	122	12	610	.10	8400	3.7
Average			658	.12		

The operation of this machine was thoroughly satisfactory in all respects so far as mechanical operation and condition of cream were concerned. Both this machine and the Baby No. 3 were belted directly to the driving shaft and of course there was no difficulty in maintaining a proper speed.

In giving these few peculiarities of the different machines nothing has been said regarding the percentage of fat left in the skim milk as that was plainly shown by the table itself. But to bring the whole matter together the summaries of the several tables have been brought together in Table VIII.

TABLE VIII.

Kind of machine.	No. of runs.	Rated capacity per hour.	Pounds separated per hour.	Per cent. of fat in skimmed milk.
1. Sharples' Standard Russian.....	20	1200	1112	.29
1a. Sharples' Imperial Russian.....	5	2000	1900	.20
2. Victoria, 75 gal.	12	625	737	.19
3. De Laval, Alpha No. 1....	14	2000	1471	.10
4. De Laval, Baby No. 3....	17	600	571	.17
5. Columbia, No. 1.....	17	300	318	.13
6. Butter Accumulator (as separator)	9	600	416	.13
7. United States Extractor Separator No. 3, (as separator).....	10	600	658	.12

An important factor in centrifugal separators is the amount of power required. This becomes an important item in the way of fuel consumption in factories doing a large business and using the larger power sizes. It is no less an important factor in muscle consumption in those machines that are intended to be run by hand. In order to get some data on this point, coöperation of the Mechanical Department of the University was asked and through the kindness of Prof. R. C. Carpenter, Messrs. L. S. Marks and S. H. Barraclough, graduate students of the Department of Mechanical Engineering, were detailed to make the test of the power required by the various machines. This work was done after the close of the term of the Dairy School and was carried on in a most careful manner by Messrs. Marks and Barraclough, both of whom have had large experience in similar work. Their Report in full is inserted herein.

**REPORT ON THE POWER REQUIRED TO DRIVE THE CREAM SEPARATORS
AT THE DAIRY BUILDING, CORNELL UNIVERSITY.**

We have, at your request, made a series of tests to ascertain the power required to drive each of the cream separators at the Dairy Building. Of these there are six; one being driven by a self-contained steam turbine, and the remaining five by belting from a power shaft. The numbers refer to the numbers of the tables giving details of the various runs.

(1.) The combined steam turbine and separator, The Standard Russian, manufactured by P. M. Sharples, of Westchester, Pa., was tested in the following way for steam consumption. All connections with the boiler, except that leading to the turbine, were carefully closed. The turbine was then run for one hour, working to its full capacity, and the weight of steam consumed was noted by observing the level of the water in the gauge glass of the boiler, weighing the feed water during the hour, and finishing with the same level in the boiler. As some leakage was noticed from the steam pipe, trials for leakage of two hours' duration were made, and the observed loss has been subtracted from the total steam consumption to obtain the amount actually passing through the turbine. The steam pressure at the boiler was 80 pounds by gauge; it was reduced to 40 pounds, by an au-

automatic reducing valve just before entering the turbine. The weight of milk separated and the speed of rotation of the turbine were noted.

The data are as follows :

Speed of rotation.....	7,000 revs. per minute.
Weight of milk passing through separator.....	1,287 lbs. per hour.
Steam consumption of turbine.....	160 lbs. per hour.

It was not found possible to measure the power absorbed by the machine.

The turbine separator cannot be directly compared with the others. A general idea of its performance may be obtained from its steam consumption which may roughly be taken as equivalent to that of a 4 horse power engine. After allowing for its greater capacity, it will be seen that it is less economical in steam consumption (assuming 40 lbs. of steam per hour equivalent to one developed horse power) than any of the other separators tested.

In each of the remaining five separators, the power absorbed was measured by an Emerson Transmission Dynamometer, placed between the driving shaft and the countershaft. Each machine was driven from a separate countershaft, supported on two bearings. Two of the machines obtained the necessary speed of rotation by means of toothed wheel gearing; the other three by belting through a second countershaft or intermediate. In each case the power measured was that required to drive the separator together with its countershaft or countershafts.

The performances of the different machines are given below :

(7). The United States Extractor Separator No. 3, by the Vermont Farm Machine Co., Bellows Falls, Vt., is driven from one countershaft and obtains the necessary speed of rotation by means of toothed gearing. It was run only as a separator. The observed data are as follows :

Weight of milk separated.....	582 lbs. per hour.
Power absorbed by separator running empty.....	.40 Horse Power.
Power absorbed by separator when separating.....	.44 Horse Power.

(4). The De Laval Baby No. 3, of the DeLaval Separator Co., No. 74 Cortlandt St., New York City, is geared in a manner similar to the preceding. The data obtained were :

Weight of milk separated.....582 lbs. per hour.
 Power absorbed by separator running empty..... .107 Horse Power.
 Power absorbed by separator when separating..... .150 Horse Power.

The remaining three separators have each two countershafts.

(6). The Combined Separator and Accumulator by the Swedish Cream and Butter Separator Co., Bainbridge, N. Y., was run in both its capacities, but no difference in the power required was observed. The power absorbed by each of the countershafts was separately measured. Data are as follows :

Weight of milk separated.....240 lbs. per hour.
 Power absorbed by separator and countershafts,
 running empty.....1.08 Horse Power.
 Power absorbed by separator and countershafts
 when separating1.115 Horse Power.
 Power absorbed by the two countershafts287 Horse Power.
 Power absorbed by first countershaft..... .096 Horse Power.
 Power absorbed by second countershaft, or inter-
 mediate191 Horse Power.
 Power absorbed by separator alone when running
 empty..... .793 Horse Power.
 Power absorbed by separator when separating...828 Horse Power.

(2). The Victoria Separator, manufactured by Watson, Laidlaw & Co., Glasgow, Scotland, The Dairymen's Supply Co., Philadelphia, Pa., agents, gave the following results :

Weight of milk separated.....702 lbs. per hour.
 Power absorbed by separator running empty.....1.835 Horse Power.
 Power absorbed by separator when separating1.948 Horse Power.

(5). The remaining separator was the Columbia No. 1, manufactured by the Columbia Separator Co., Avon, N. Y., from which the following data were obtained :

Weight of milk separated.....353 lbs. per hour.
 Power absorbed by the separator running empty....1.100 Horse Power.
 Power absorbed by the separator when separating...1.124 Horse Power.

The above results show a somewhat surprising variation in the mechanical efficiencies of the separators tested. The power required to drive two of the machines, No. 4 and No. 2, of not very different capacities, is seen to be .15 and 1.95 horse power respectively, a variation large enough to arouse a suspicion as to the accuracy of the results, were it not that the other tests show a gradation in power required, between these two values.

The friction of the machine is seen to absorb in each case the

major portion of the power expended, while the actual work in separating the milk appears to be roughly proportional to the weight separated. The work done in separating is about .07 horse power per thousand pounds per hour.

A noteworthy conclusion to be drawn from the test is, that the geared form of separator is much more efficient than the belted form. This may be due in part to slipping of the belts at the high speed used. Much work is also absorbed in bending the belt as it passes around the small pulleys.

It may also be noted that the two machines, No. 6 and No. 5, in which rope belts were used, were considerably more efficient than No. 2 in which a leather belt was employed between the intermediate and the machine.

S. HENRY BARRACLOUGH,
LIONEL S. MARKS.

The following table has been compiled from the report of Messrs. Barraclough and Marks and shows not only the absolute horse power required for each machine but also the relative power based upon a capacity of 1000 pounds per hour. It will be noticed in regard to the butter accumulator that the capacity as given in the trial of Messrs. Barraclough and Marks is 240 pounds. This was the capacity noted while the machine was running as an accumulator but as the power required was the same both as an accumulator and as a separator and as the machine has been used mostly as a separator, we have calculated the horse power per hour upon a basis of a capacity of 416 pounds per hour as a separator :

TABLE IX.

Kind of machine.	Average pounds separated per hour.	Pounds separated per hour in power test.	Horse power required.	Horse power for 1000 lbs. per hour separated.
Sharples' Standard Russian.....	1112	1287	4.	3.13
United States extractor separator No. 3 (run as separator)	658	582	.44	.76
De Laval baby No. 3.....	571	582	.15	.26
Butter accumulator (as separator and as accumulator).....	416	240	1.12	2.69
Victoria	737	702	1.95	2.78
Columbia No. 1.....	318	353	1.12	3.17

In regard to the simplicity of construction and ease of cleaning and keeping in order of the various machines there is no very great distinction. Some of the machines have points of superiority over the others in these respects, but none are so complex in working parts or so difficult of thorough cleansing as to raise any considerable objection to their use.

In conclusion it should be borne in mind that these are tests of single machines of the various kinds, that they were run under conditions fully as favorable as are found in ordinary factory work so far as installation and skill of operation were concerned, but under less favorable conditions, if stopping and starting are sources of loss, than in ordinary factory management because only small amounts of milk were separated at one time.

HENRY H. WING.

50.679
N7
C82b

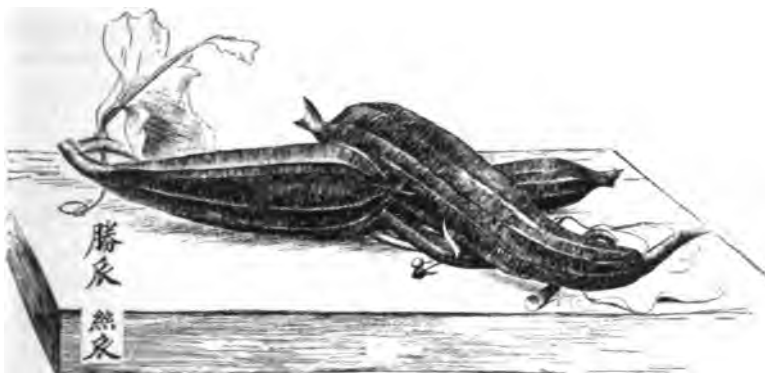
Bulletin 67.

June, 1894.

Cornell University Agricultural Experiment Station.

HORTICULTURAL DIVISION.

SOME RECENT CHINESE VEGETABLES.



By L. H. BAILEY.

PUBLISHED BY THE UNIVERSITY.

ITHACA, N. Y.

1894.

ORGANIZATION.

BOARD OF CONTROL: THE TRUSTEES OF THE UNIVERSITY.

STATION COUNCIL.

President, JACOB GOULD SCHURMAN.

Hon. A. D. WHITE,	-	-	-	-	Trustee of the University.
HON. JOHN B. DUTCHER,	-	-	-	-	President State Agricultural Society.
I. P. ROBERTS,	-	-	-	-	Professor of Agriculture.
G. C. CALDWELL,	-	-	-	-	Professor of Chemistry.
JAMES LAW,	-	-	-	-	Professor of Veterinary Science.
A. N. PRENTISS,	-	-	-	-	Professor of Botany.
J. H. COMSTOCK,	-	-	-	-	Professor of Entomology.
L. H. BAILEY,	-	-	-	-	Professor of Horticulture.
H. H. WING,	-	-	-	-	Asst. Professor of Dairy Husbandry.
G. F. ATKINSON,	-	-	-	-	Asst. Professor of Cryptogamic Botany.

OFFICERS OF THE STATION.

I. P. ROBERTS,	-	-	-	-	Director.
HENRY H. WING,	-	-	-	-	Deputy Director and Secretary.
E. L. WILLIAMS,	-	-	-	-	Treasurer.

ASSISTANTS.

M. V. SLINGERLAND,	-	-	-	-	Entomology.
GEO. C. WATSON,	-	-	-	-	Agriculture.
G. W. CAVANAUGH,	-	-	-	-	Chemistry.
E. G. LODEMAN,	-	-	-	-	Horticulture.

Offices of the Director and Deputy Director, 20 Morrill Hall.

Those desiring this Bulletin sent to friends will please send us the names of the parties.

BULLETINS OF 1894.

62. The Japanese Plums in North America.
63. Co-operative Test of Sugar Beets.
64. On Certain Grass-Eating Insects.
65. Tuberculosis in Relation to Animal Industry and Public Health.
66. Test of Cream Separators.
67. Some Recent Chinese Vegetables.

RECENT CHINESE VEGETABLES.

In recent years there has been a distinct infusion of Chinese and Japanese plants into our vegetable gardening. For the most part these plants are little known, even to the seedsmen who offer some of them as novelties, and it seems to be important that some definite account should be made of them before they become generally distributed and greatly modified, and while yet the history of their introduction is as little complicated as possible. It was some five years ago that the present writer took up their study, the results of which are presented in the following paper. It was at first thought that the botanical problems growing out of this study would be of easy solution and that little need be done in the final report but to narrate the behavior of the plants in the garden ; but it was soon found that some of the types are almost inextricably confused, and that there are garden plants which have been long cultivated in this country which are undoubtedly of oriental origin, but the history of which is wholly unknown and which, furthermore, are not described and probably not mentioned in any American writings. The experiments with these Chinese vegetables, therefore, have enforced upon me again the importance of critical studies of garden plants—to which few American students have given their attention,—not only for the purpose of arriving directly at economic results, but quite as much for the elucidation of the broader problems of the variation of plants under new conditions of life and for the discovery of the means by which they may become widely distributed over the face of the earth and in the very centers of civilized countries without attracting a passing notice from naturalists.

These Chinese vegetables which I have here described, might be thrown into two categories with respect to their introduction into North America. The first group would include some of the better known species, like the so-called cabbages, which have

been in the country some years and have been regularly sold by reputable seedsmen both of Europe and America. The second group would include those which are brought in by the Chinese gardeners about some of the great cities, and which are almost unknown to the American planter or catalogue reader. I have taken some pains to secure these plants of the celestial gardeners, and my experiences have been often better suited to narrative than to instruction. The Chinese gardener, upon his scrupulously tilled bit of land, is suspicious of an intruder and he hesitates to part with his seeds for fear of disastrous competition; but we have, first and last, I think, been able to secure and grow nearly every vegetable which is grown by the Chinese about New York and Boston. And there are few of them which are worth transferring to our gardens.

But with the Chinese names and descriptions, things have not gone so smoothly. The Chinese language abounds in dialects and the gardeners whom I have visited either could not or would not write the Chinese characters; or, if they had, matters would not have been simplified. I finally received great aid from Mr. Wah Hang, of Boston, upon whom I am glad to place the responsibility of most of the Chinese characters in the following pages. I have also had the advantage of valuable suggestions from Mr. L. Wing, of the Chinese Consulate in New York City.

I. CABBAGES AND MUSTARDS.

Pe-Tsai. (Brassica Pe-Tsai.)

The Pe-Tsai, or Chinese cabbage, is no longer a novelty in American gardens, although it does not appear to be well known and its merits are not understood. Its cultivation and peculiarities were described in France so long ago as 1840 by Pépin, who says that, while the plant had been known in botanic gardens for twenty years, it was brought to notice as a culinary vegetable only three years before he wrote. It appears to have attracted little attention in Europe until very recent years, however, and it is still included in the second edition of Paillieux & Bois' "Kitchen Garden of a Virtuoso," * 1892. It began to attract attention in the United States probably about ten years ago.

* *Le Potager d'un Curieux, Paris.*



Pe-Tsai, or Chinese White Cabbage.

The Pe-Tsai (or "white cabbage") of the Chinese, is properly an annual plant, which has much the habit of a Giant Cos lettuce. The illustration on page 179 shows an excellent specimen, when



Santo-Tsai, from a Japanese drawing.

ready for cutting. A Japanese drawing of the plant is shown upon this page. The name of this particular Japanese variety, as written in the characters at the right, is Santo-Tsai, a variety which we have grown three or four years. The characters at the bottom explain that it was raised in the Mita gardens at Tokio.

The Pe-Tsai needs a moist and cool soil for its best development. If the plants are left too long in a seed-bed they tend to run to seed, and they do the same if set upon a hot and dry soil.

The plant is nearly as hardy as the ordinary cabbage, and takes advantage of the cool weather of September to make its best leaf growth. We have usually sowed the seeds in June in a seed-bed, transplanting the plants before they begin to crowd, and procuring the heads in September and October; but if a cool and uniformly moist, generous soil can be provided, the plants may be started late in July or in August with good results.

The head of the Pe-Tsai is never solid like that of the cabbage, but is rather a long and loose roll of soft leaves, the inner ones becoming blanchéd and very crisp. In order to keep the head compact and tender, its top should be tied together, when nearly mature. An average core, or compact portion of the head, will measure ten or twelve inches in length, by a third or half as great

diameter. The one illustrated on p. 179 weighed 3 lb. 6 oz. The head is eaten in the same manner as ordinary cabbage, and it affords a very excellent dish. It is somewhat milder and sweeter than the cabbage. In China, I am informed, the plant is often served uncooked, being shredded with sugar and vinegar. If well grown, it is excellent eaten raw.

We rarely secure heads from all the plants. In fact, in making many experiments, we have only once secured what could have been called a good crop, and in this instance the plants grew upon a moist or even wet clay loam. A correspondent in China states that the plants need to be well watered. But I am convinced that some of our unsatisfactory crops are to be charged to poor seed. There is no systematic attempt to grow the plant for market, and therefore little selection is practiced in the choice of plants and strains for seed-bearing; and as the plant runs so quickly to seed in dry soils, it is easy for the stock to soon deteriorate. A Japanese horticulturist, to whom I stated my difficulties, confirmed my suspicions by saying that the grade of seeds has a marked influence upon the crop.

We have grown this interesting cabbage from several sources, and we have found little variation in the form and type of head, although the foliar and some other characters of the plants are perplexingly variable to one who desires to study them with reference to their botanical features. The Shantung Cabbage,* grown from seed furnished by the Royal Gardens at Kew, England, is somewhat dwarfer, but it does not appear to differ in other respects from the ordinary type. Another variety, which we have obtained from New York Chinamen, is called *Luon*. The Chinese cabbage is always distinguished from related species by its very wide and winged petioles or leaf-stalks, which remind one strongly of the leaf stalks of the salad beet or Swiss chard.

Pe-Tsai is probably a native of China, although its aboriginal form does not appear to be understood. It is much cultivated

* Introduced in England in 1887. "It grows in the north of China, is lettuce-shaped, and weighs from 5 to 8 lbs. . . . It is an autumn cabbage, should be planted about 18 inches apart, thrives best with moisture, and in Shantung is watered every day; there the seed is sown in June."—*Kew Bulletin*, May, 1888, 137.

there, and also in Japan. Professor Georgeson* makes the following account of it in Japan :

"No other vegetable of this class is so universally grown, or is represented by so many varieties. It is a kind of rape which has been transformed by cultivation. Certain varieties of it are grown only for their seed, from which an oil is expressed, formerly much used as lamp oil. This class of illuminating oil is, however, rapidly passing out of date, its place being taken by American kerosene. . . . The term cabbage is a misnomer, as its resemblance to that vegetable is quite remote. The plants are merely bunches of large, smooth, more or less spreading leaves, with broad fleshy midribs. They do not bear their leaves on a well defined stem, as do the cabbage, kale, etc., but look more like the Cos lettuce, the leaves having their origin at the surface of the ground. They are usually cultivated as a fall crop and grow very rapidly, some varieties attaining a height of two or three feet in two months from the seed. The seed is usually sown early in September. When large enough, the plants are set out in rows like cabbage, the distance varying with the size of the varieties. For rapid growth they require a rich soil, and good cultivators stimulate their plants by applications of liquid manure every eight or ten days. By the end of October the crop is ready for use and it is cut and marketed before frost. In taste, all varieties are much alike. They have the characteristic flavor of the Cruciferæ in a wild form. This flavor is improved by blanching, which is commonly done either by simply tying up the leaves or by heaping the earth up about them. Thus treated, the leaves make a crisp and palatable salad. They are also boiled for greens, and enter into the composition of many dishes. Why might not this class of cabbage find similar uses in this country? It would especially compare favorably with the collards so largely grown for the southern markets, and which are merely varieties of non-heading cabbage of tough fibre and strong taste. Some of the large varieties might also be of value for stock feed.

"This species is not hardy ; it must be harvested before frost. It is, in fact, chiefly grown for winter use. For this purpose it is

* Amer. Gard. xii. 652 (Nov. 1891).

packed closely in tubs, with thin layers of common salt scattered through the mass. It soon undergoes a fermentation, which converts it into a kind of sauerkraut called *Natsuki*, which can be kept all winter and drawn upon at pleasure. There are many varieties, the following being some of the leading ones: *Hakusai*, *Shirakuki-na*, *Tojin-na*, *Santo-sai* (see cut, p. 180), *Mikawashima-na*, *Komatsu-na* and *Uguishu-na*."



Pak-Choi.—(*Brassica Chinensis*.)

The Pak-Choi*, commonly called Chinese cabbage and frequently confounded with the Pe-Tsai and apparently always (but, I believe, erroneously) referred to the same species, is a vegetable which never forms a head, and which appears to be normally biennial, although it freely runs to seed the first season if left in the seed-bed or grown upon dry soils. The engraving above is an excellent illustration of a well grown plant. Unlike the Pe-Tsai, the leaves are borne upon long and marginless stalks, and they spread in all directions, like a turnip top. These leaf-stalks are light colored, sometimes almost ivory white and celery-like, and are

*The word for "greens" is spelled *Choi* and *Choy*, when rendered in English characters, but Mr. L. Wing, of the Chinese Consulate, New York, tells me that the former spelling more nearly conforms to the Cantonain pronunciation.

the most edible portion, being cooked and served after the manner either of cabbage or asparagus. The entire foliage is cooked as "greens," however. The plant is curious and affords an acceptable variety for the kitchen-garden, but I cannot see that it is des-



TUBEROUS ROOT OF PAK-CHOI.

tined to become even an important secondary vegetable in America. The plant requires a somewhat longer season than the Pe-Tsai.

I have said that this plant is apparently normally biennial. Most of the plants, if given cool, moist soil, tend to make a turnip-like root, like that shown in the engraving above. These roots are not unlike turnips in flavor. A patch was sown May 23, 1893, to Pe-Tsai and Pak-Choi, the plants not being transplanted. On November 19, when the last notes were taken, the Pe-Tsai plants had all perfected seeds and were dead, but most of the Pak-Choi plants were still growing, and had thick tuber-like roots.

This plant is so uniformly associated with Pe-Tsai in horticultural writings, that I am unable to separate its individual history. It is undoubtedly native to China. There are many forms of it. We have grown it in two varieties from Japanese sources, and from the Chinese about New York we have it under the names *Bok-toi-moi* and *Choi-toi-moi*.

California Peppergrass. (*Brassica Japonica*). PLATE I.

In 1890, John Lewis Childs introduced the California Peppergrass, with the following description: "Some years ago, we received from a customer a sample of seed which was called Cali-

forma Peppergrass. It was recommended as being extra fine for salads, dressing and garnishing, and unlike anything else known. We find it a very beautiful and valuable thing, and unlike anything else of the sort. It seems to be halfway between a cress and a mustard. Its leaves are long and narrow, deeply lacinated, fimbriated and crinkled, making it one of the prettiest green foliage plants we ever saw. To the taste the leaves are sharp, and have much the flavor of peppergrass. It is excellent when mixed with lettuce or other salads to which it imparts a very fine flavor. For garnishing there is nothing more beautiful. It grows very quickly, and to keep up a succession all summer several sowings must be made. We think its flavor much improved if bleached a few days before cutting by covering with boxes or boards." Our own experience with the plant confirms the above account of its behavior. It is one of the best plants for early spring "greens," as it grows very quickly, is hardy, and it makes a very compact tuft of crisp and beautiful leaves. The illustration in Plate I shows a plant when in condition for the table, but the specimen from which the photograph was taken was wilted, so that the compact growth of the young plant is not apparent.

I recognized this plant as a probable cut-leaved and crinkled form of a garden mustard which I had known from boyhood, but the botanical position of which I had never been able to determine. There is a tradition in the family that the seed of this mustard was brought into western Michigan in the early days from Maryland. In my father's garden, the plant has maintained itself for at least twenty-five years, coming up early each spring from self-sown seed. The crisp tufts of May herbage have always been a favorite for spring "greens." I have also found this plant, with leaves almost as much cut as in the California Peppergrass, in a garden at Lansing, Mich., and John K. Small has collected the same form "about the neglected garden of Wells Miller, on the summit of White Top Mountain, Washington Co., Virginia."*

The plant appears, therefore, to be widely distributed in this country, and the wonder is that neither American horticulturists nor botanists appear to have made any record of it; and I am not able to trace it in the garden literature of Europe. It appears to

* Specimen in Torrey Herbarium, Columbia College.

be the *Sinapis Japonica* of Thunberg, and a native of Japan or China; and I am led the more confidently to refer it to this species as Mr. Wah Hang says that he recognizes the form cultivated as California Peppergrass, to be the *I-how-toi* of the Chinese. In the Japanese botanical serial, *So Mokou Zoussetz*, vol. xi. folio 38, is a good figure of the California Peppergrass form, under the name of *Sinapis Japonica*, or *Chirimen-na* of the Japanese gardens. I do not know how extensively this vegetable is cultivated either in China or Japan. Professor Georgeson* speaks of the "*Midzu-na*, still another species which perhaps furnishes the most favorite varieties," and says that the plant is *Sinapis Japonica*. "One of these varieties which originated in Yamashiro, is called *Sensuji*. It is remarkable for the large number of leaves produced by a single root, and the leaf is narrow and deeply and irregularly cut. All these mustards are sown in the fall and used for greens in the winter, being gathered as wanted. In cold situations I have often seen the rows partially protected by leafy bamboo branches stuck thickly in the ground. The market gardeners on the east side of Tokio make a specialty of this winter crop." But the Japanese serial quoted above, refers (folio 33) the *Midzu-na* to *Sinapis Chinensis* of Linnæus, quite a different plant, in my opinion, from *S. Japonica*, although Professor Georgeson unites the two in his account.

Chinese Mustard. (Brassica juncea.) PLATE I.

Under five names we have grown mustards which appear to be varieties of one species. These plants are the Chinese Broad-leaved mustard (Thorburn) and the *Moutarde de Chine à feuille de Chou* (Vilmorin), which are identical; Chinese mustard (Thorburn, Rawson, Vilmorin); Brown mustard (Rawson); and *Brassica rugosa* from the Royal Gardens, Kew, England. The upper engraving in Plate I is an excellent likeness of the form sold as Chinese mustard by Vilmorin. This is the *Choi-toi* of the Chinese. The plant is very rank and coarse in its growth, the large rugose and roughish leaves often standing two feet high in moist soil. But even in this rank state, we have found the plant to have distinct value as a pot-herb. It cooks tender, and has a

*Amer. Gard. xii. 653.

warm, half-pungent flavor which is very agreeable. Like other mustards, if these large leaves are desired, the plant should be given a cool soil and the best growth should be expected in spring or fall. The photograph in Plate I was taken on the 21st of October. We have found this plant excellent for forcing, for winter "greens" (see Bull. 55, p. 143).

Brassica juncea, as now accepted by botanists, is held to include a great variety of forms. It is native to tropical and temperate Asia, and is widely cultivated in the Old World. According to Hooker and Thomson,* it affords the Soorsa mustard of India, which is cultivated for oil and burning, and rubbing the body in illness. Professor Georgeson speaks of its cultivation in Japan as follows:†

"*Taka-na*, *O-garashi*.—This species is not a native of Japan. It is indigenous to Africa and China, from which latter place it has doubtless been introduced. It is a large plant, as is indicated by the native names, one meaning 'tall greens' and the other 'large mustard.' It is hardy, and is usually sown in the fall, in rows two feet apart, for winter use. The leaves are large, spatulate or obovate, the radical ones often a foot long, the lower portion of the margin dentate, and the upper portion entire or slightly sinuate. It is highly esteemed for salad, and is used all winter long. Certain varieties are also grown for the seeds, which are used both for condiment and as a source of oil. It is said to be cultivated in all parts of India for the seed, which is exported under the name of Sarepta mustard seed."

Tuberous-Rooted Chinese Mustard. (Brassica napiformis).

This vegetable appeared in France in 1882 from seeds sent by Dr. Bretschneider, of the Russian legation, Pekin.‡ It was offered by American seedsmen as early as 1889.|| The plant is a biennial, with thin bluish foliage, and a small tuberous root like a conical turnip. These roots, which reach a diameter of three or

* Journ. Linn. Soc. v. 170.

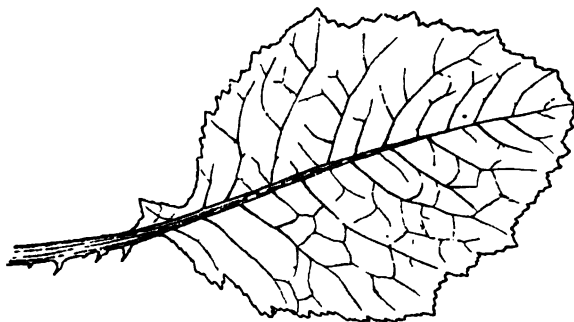
† Amer. Gard. xii. 653.

‡ Paillieux and Bois, *Le Potager d'un Curieux*, 2d ed. 372.

|| Annals of Horticulture, 1889, 121.

four inches, are scarcely distinguishable from white turnips in appearance, texture and flavor. I have not yet discovered sufficient merit in the plant to warrant its general cultivation in this country. In China the tubers are used as a winter vegetable, the seeds being sown in summer.

The plant is native to China. It does not appear to have been brought to the attention of botanists until Bretschneider published an account of it in a French journal in 1881. Pailieux and Bois



Lower Stem-leaf of Tuberous Rooted Mustard.

regard it as a variety of *Brassica juncea*, to which the Chinese mustard belongs, but it is very different from that plant, and I am forced to consider it a distinct species.

It is more nearly related to Pak-Choi than to any other plant which I know, and it may have sprung from the same species; but it is clearly distinguished by its sharply toothed leaves, one of which is shown in the accompanying figure.

Botanical Characteristics of These Cabbages and Mustards.

In common with all members of the genus *Brassica*, or Cabbage and Mustard tribe, these Chinese plants are much confused respecting their botanical characters. Recent writers* have referred all the Chinese Cabbages to *Brassica campestris*, the Ruta-Baga; but one who studies the plants carefully both from herbarium and living specimens, cannot long hold this opinion. The genus *Brassica* divides itself naturally into two groups,—the cabbages and rape, characterized by thick leaves, very glaucous-blue herbage and long flowers which are creamy white, and the mustards, with thinner and green or lightly glaucous herbage and small bright yellow flowers. The Chinese cabbages belong to this latter group rather than to the former. Their flowers are those of the mustards, and I have no hesitation in removing the plants from *Brassica campestris*.

* See, for instance, Kew Bulletin, May, 1888, 138; Forbes & Hemsley, Journ. Linn. Soc. xxiii. 46.

There is even good reason for separating the two types of Chinese cabbage—the Pe-Tsai and Pak-Choi—into two species, for they differ widely in their leaf characters and pods; and the former is truly annual, while the latter is evidently normally biennial. The Chinese cabbage has been understood to be the *Brassica Chinensis* of Linnæus, but Linnæus' description is not explicit and it does not fit the Pe-Tsai, although it designates fairly well the characters of Pak-Choi. The remarkably broad-winged flat petioles would not have escaped Linnæus' description if he had had the Pe-Tsai type before him, and his comparison of the foliage to that of the cynoglossum suggests Pak-Choi rather than Pe-Tsai. Louriero, however, explicitly describes the Pe-Tsai as *Sinapis Pekinensis* var. *Pe-Tsai*, and I have raised this variety to specific rank under *Brassica*, the genus with which *Sinapis* is now united by most botanists. I have ventured to use Linnæus' name for the Pak-Choi, although it is impossible, without an examination of his herbarium, to determine the plant which he had in mind.

The tuberous rooted Chinese mustard is regarded as a variety of *Brassica juncea* by Paillieux and Bois, but it is widely different from that plant, not only in its biennial character but in distinct leaf characters and glaucosity. It is most closely allied to Pak-Choi, but the leaf characters in the two are so unlike that I have felt obliged to regard them as distinct species.

The five types of Chinese cabbages and mustards here considered may be distinguished as follows:

* *Plant potentially biennial (i. e., the root hard and thickened, often distinctly tuberous); foliage firm in texture.*

1. *BRASSICA CHINENSIS**, Linn. Amœn. IV. 280 (1759). PAK-CHOI, etc. Radical leaves numerous and large, glossy-green, obovate or round-obovate in general outline and entire or obscurely wavy or crenate, tapering into a distinct thick petiole, which is not at all or very little margined or sometimes with a few leaf-like lobes; flowering stem and its leaves more or less glaucous, the leaves obovate or oblong and clasping; flowers light yellow; pods large and long and rather slender (about 3 in.) and firm, tapering into a cylindrical and sharp beak a half inch long.

Linnæus' description of the species is as follows:

"*Brassica (chinensis) foliis ovalibus subintegerrimis, floralibus amplexicaulis lanceolatis, calycibus ungue petalorum longioribus.*

"Habitat in China. Dn. Osbeck attulit semina.

"Descr. Folia oblonga seu ovalia, simillima cynoglossis, obtusa sed glabra; caulina amplexicaulia, oblonga, integerrima. Flores, ut in *Brassica oleracea-lutei*. Calyx unguibus petalorum longior, unde hians and interpetala prominens. Stamina longiora. Siliquæ parum compressæ."

2. *BRASSICA NAPIFORMIS*. TUBEROUS-ROOTED CHINESE MUSTARD.

Sinapis juncea, var. *napiiformis*, Paillieux and Bois, Le Potager d'un Curieux, 2nd ed. 372 (1892).

**Sinapis Chinensis* of Linnæus, is a different plant.

Radical leaves much less numerous, the blade thin and oval in outline and on long and slender, slightly feathered petioles, sharply and irregularly toothed, with a thin bloom; lower stem leaves much like the radical ones, but the uppermost oblong-lanceolate and clasping; flower stems (very tall) lightly glaucous-blue, the flowers bright yellow; pod much as in Pak-Choi, except that the beak is abrupt and very slender.

****Plant truly annual; foliage loose and soft.**

3. BRASSICA PE-TSAI. PE-TSAI, etc.

Sinapis Pekinensis, var. *Pe-Tsai*, Louriero, Flora Cochinchina, 400 (1790).

Radical leaves numerous and large, light colored, oblong or obovate-oblong, soft and crinkled and very veiny, the margins wavy, the wide lower portion comprising a flat ribbed petiole 1 to 3 in. wide which is margined by a wavy or notched wide and thin wing; lower stem leaves notched or crinkled-margined, the upper oblong-oval or oblong-lanceolate, all sessile and clasping and more or less glaucous; flowers light yellow; pod short (about 1½ in.) and thick, softish, much broader and softer than in Pak-Choi, very gradually narrowed into a cone-like short point.

Louriero's description of the plant is as follows:

"*Sinapis Pekinensis*. var. *Pe tsái*. a *Cai bën*.

"Differ. spec. *sin. foliis turbinato-ovatis, integris, crispis: petiolis sub-planis, latis: silisquis glabris, planiusculis.*

"Hab., et notae. *Caulis annuus, 2 pedalis, erectus, crassus, teres, glaber. Folia radicalia turbinato-ovata, integra, serrato-runcinata, crispata, glabra, flavescentia, tenerima: petiolis sub-planis, latissimis, albis, sulcatis, semiamplexicaulibus: caulina conica, sessilia integerrima. Spicæ solitariae, longissimæ, patentes. Calycis foliola 4, oblonga, obtusa, erecta, lutea. Corolla similiter lutea, 4-petala, patens. Siliquæ lineares, compressæ, glabræ, 2-loculares: seminibus globosis, rufis.*

"*Habitat Pekini culta, ubi omnium optima. In Cochinchinâ altius crescit, inferior qualitate. In Lusitania satam, et plantatam servo, sed quotannis in peius degenerantem.*

"*Observ. Attendens ad varietates Brassicæ oleracæ in Europa cultas, et facie inter se valde differentes dubitare cæpi, non omnes istæ sinapis plantæ dici etiam debeant varietates, non diversæ species?*

Virtus. Fere eadem, quæ præcedentium, sed debilior."

4. BRASSICA JAPONICA, Siebold; Miquel, *Prolusio Floræ Japonicæ*, 74 (1865-6); Georgeson, *Amer. Gard.* xii. 653 (1891), in part. *Sinapis Japonica*, Thunberg, *Flora Japonica*, 262 (1784). CALIFORNIA PEPPERGRASS, etc.

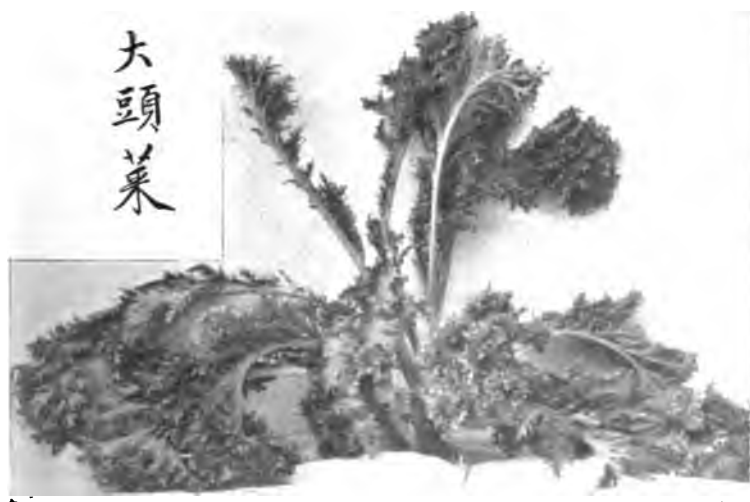
Radical leaves rather many, oblong, or oblong-obovate, the margins either crisped or the whole blade cut into many fern-like curled and crisped divisions; stem-leaves toothed or cut, all petioled, usually very glaucous, as well as the stem; flowers small, yellow; pods much smaller than in the preceding three species, with a gradual slender beak.

The *Sinapis Japonica* of Thunberg is undoubtedly the plant which we are considering. There is some question, however, if the *Brassica Japonica* of

PLATE I.



Chinese Mustard.—Brassica juncea.



California Peppergrass.—Brassica Japonica.

PLATE II.

La-kwa, Momordica Charantia. A curious vine of the Pumpkin family, much used by the Chinese in various culinary preparations.



Sua-kwa, or Dish Cloth Gourd.—Luffa cylindrica.

Siebold is the same. This latter plant is known only by the following incidental reference to it by Miquel:

"*Brassica Japonica* Sieb., in Europa eseminibus Japonicis educta, cum *Sinapi Japonica* Th., floribus congruit, diagnosin *S. auriculatae* DC., haud repudians, nobis ob sp. incompletum nimis incerta."

It has seemed better, however, to accept Siebold's species to be the same as Thunberg's—inasmuch as there is no evidence that it is not the same—than to propose a new name for our plant.

5. *BRASSICA JUNCEA*, Coss. Bull. Soc. Bot. France, vi. 609 (1859).

Sinapis juncea, Linn., Sp. Pl. 668 (1753).

Radical leaves generally abundant and often very large, oval or oboval in outline, the blade angled or toothed, tapering into a narrow petiole which generally bears leafy appendages; lower stem-leaves more or less toothed and petiolate, the upper ones oblong or oblong-lanceolate and entire and closely sessile or clasping; flowering stems and leaves more or less lightly glaucous; flowers bright yellow; pod slender, of medium size, tapering into a short beak.

This much abused species is held by Hooker and Thomson (Journ. Linn. Soc. v. 170) to include a great variety of forms, as *Sinapis lævigata*, Linn., *S. integrifolia*, Willd., *S. ramosa*, *rugosa*, *patens*, *cuneifolia*, Roxbg., *S. lanceolata*, DC., and others. There are two types of it in cultivation in our gardens, one with the radical leaves somewhat sharply toothed and nearly smooth below (comprising the Kew *Brassica* (or *Sinapis*) *rugosa*), the other with root leaves obtusely toothed and spinescent on the veins below (comprising Chinese mustard, Chinese Broad-leaved mustard and Brown mustard). Linnaeus founded his *Sinapis juncea* upon a figure in Hermann's *Paradisus* (Hermann, *Paradisus Batavus*, t. 230. 1705), which represents a plant very like the former type mentioned above, and which Hermann described as lettuce-leaved.

II. CUBURBITS.

Zit-kwa,* or Chinese Preserving Melon. (*Benincasa cerifera*).

This plant appears to be a common inhabitant of Chinese gardens. Under the name of Chinese Preserving melon, it was introduced in 1892† by John Lewis Childs. I am told that in the Chinese quarter of San Francisco it is known as Chinese water-melon. The plant is one of the melon family, and is well known as a garden esculent in India, where it is native, and in other Asiatic countries. The aspect of the vine is not unlike that of a

*Mr. L. Wing regards *Kwa* as the best spelling of the Chinese word for squash or gourd. Bretschneider, however (*On the Study of Chinese Botanical Works*, etc.), uses *Kua*. It is sometimes spelled *qua*.

†*Annals of Horticulture*, 1892, 181.



Zit-kwa, or Wax Gourd. Also known as Chinese Preserving Melon and Chinese Water Melon.—*Renincasa cerifera*.

rank and hairy muskmelon vine. The fruit is round or oblong, with a solid white flesh and small white seeds. The exterior is greenish and hairy, and covered with a film of white wax-like substance (whence the name *cerifera* or *wax-bearing*). It ordinarily reaches a length of ten to fifteen inches. In the books, the fruit is known as the wax gourd. In India, according to Firminger,* it is called pumpkin and white gourd by Europeans. The culture is similar to that of the muskmelon. I do not know how the Chinese use this fruit. Vilmorin† writes that the fruits are eaten the same as squashes, and that the character of the flesh is intermediate between that of the squash and cucumber. Paillieux and Bois‡ say that it is "prepared like the cucumber, to which, to our taste it is much preferable." I have been unable to relish the fruit when uncooked, but made into preserves or sweet pickles it is one of the best of all subjects for the purpose, and it is worthy general cultivation for such culinary use.

La-kwa. (*Momordica Charantia.*) PLATE II.

This plant is well known as a condiment and ingredient of curries and other table preparations, in the tropics, especially of the Old World, where it is native. It is also grown as an ornamental vine, and for this purpose is sold by American seedsmen, along with the allied species, *Momordica Balsamina* or Balsam Apple. The plant is a vine, reaching a length of ten feet, and often covering the ground with a mat of attractive herbage and yellow, soft flowers. The leaves are cordate-ovate in general outline, but are cut into five more or less toothed lobes. The fruit in the common form is oblong, six or seven inches long and covered with wart-like tubercles. This fruit is borne upon a slender stem of its own length, or more, and which bears a small leaf-like appendage at some distance back of the fruit. This appendage is entire or continuous in outline in this species, but in the true Balsam Apple (*M. Balsamina*) it is distinctly toothed. The fruit of the La-kwa splits into three divisions at maturity, disclosing many rounded, bright scarlet bodies. These bodies are edible,

* Manual of Gardening for India, 3d ed. 126.

† Les Plantes Potagères, 2nd. ed. 37.

‡ Le Potager d'un Curieux, 2nd. ed. 44.

and they comprise a pulpy mass (known to botanists as an aril) with a flat, squash-like, white or brown seed in the center. The seeds are curiously carved or marked upon the sides, and I have received them for planting, under the name of "Art Pumpkin."

This plant is a favorite with the Chinese, but I doubt if it will meet any considerable favor with Americans as an esculent. A writer in *Garden and Forest** calls it *Foo-qua*, but I have never heard this name applied to it. The name *La-kwa* is said to mean "bitter squash." The bitter rind is dried as a medicinal preparation. The fruit is prepared in various ways, when immature. The seed masses are dried, and in this condition are mixed with meat and are used in preparations of appetizers. The plant is also commonly cultivated in Japan,† under the names *Tsurureishi* and *Niga-uri*. The various methods of preparing the fruit for table use in China, are given as follows by Edward Wilmann in a foreign publication: ‡

"This fruit, which attains an average-length of three to four inches, is always gathered and used before it is ripe. When ripe it is useless from a culinary point of view. Some prefer it when it is still tender, while others do not relish it before it possesses some consistency. In either case, it is in good condition until it matures. For the table it is prepared as follows:

"*In salad.* The fruit is cut lengthwise into halves, and the seeds are removed. These two parts are then put into a sauce made of vinegar, olive oil, ginger, garlic, all-spice, salt, etc. It is customary to add to this also some cucumber, cabbage, carrot, mango, etc.

"*Pickles.* After having removed the seeds, the fruit is cut in circular slices, and is then seasoned with citron juice, all-spice, ginger, etc.

"*In cari.*|| The fruit, having been cut into two pieces, is prepared by boiling with fresh or salt bacon, or with fresh or salt

*E. T. Lander, "Chinese Horticulture in New York," *Garden and Forest*, i. 483.

†Tamari, Trans. Amer. Hort. Soc. iv. 79; Georgeson, Amer. Gard. xiii. 526 (with illustration).

‡Paillieux & Bois, *Le Potager d'un Curieux*, 2d ed. 335.

|| Cari is a condiment powder made of all-spice, curcuma, and other spicy powders.

fish. *Cari* may be added if desired, but the common southern condiments are in general use.

"In India the fruit is sliced and then fried. It is necessary, however, to boil it in water first, in order to remove all bitterness."

Sua-kwa. (*Luffa cylindrica*). PLATE II.



THIS plant we have grown from several sources, and under a variety of names, as Dish Cloth Gourd from American seedsmen, *Naga ito-uri* from Japan, and *Luffa Fabiana*, *L. Japonica* and *L. noctiflora odorata*.^{*} I have not seen this plant in Chinese gardens, but Mr. Wah Hang tells me that it is well known in China, where it is called *Sua-kwa* or "water squash." It is widely distributed in all tropical countries, and its nativity is uncertain, but it is probably indigenous to Asia. It is a cucumber-like vine, bearing slender cylindrical curved fruits which, in our gardens, reach a length of one to two feet, although in warmer countries the fruits of some varieties are said to reach nine feet in length. The fruit of this species is well shown in the lower figure Plate II. It is destitute of ridges, and this character distinguishes it from *Sing-kwa*, which is described in the following pages. There are also good leaf characters to separate the two. This plant, the *Sua-kwa*, has distinctly 5-lobed leaves, while the other has rounded and angled or shallow-lobed leaves. These characters are all admirably drawn in an article and illustration by Professor Georgeson in the *American Garden* for September, 1892, but the plant is referred to the wrong species.

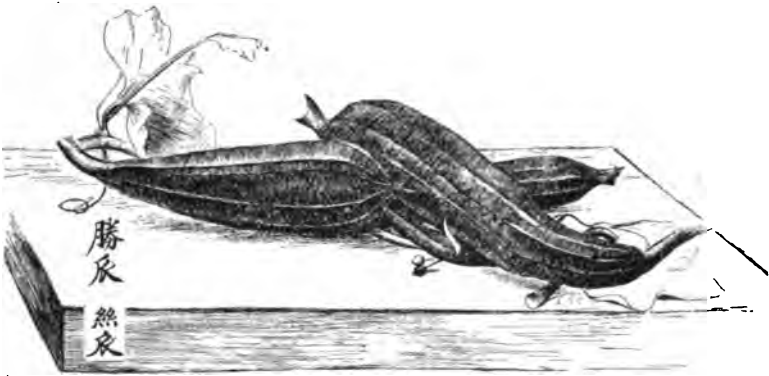
The fruit is eaten before it is mature, either sliced like cucumber, or in soups, or cooked like squash. In Japan, according to Professor Georgeson, the young fruit is sliced and dried and thus preserved for future use. The fibrous interior of the mature fruit has a sponge-like texture, and when cured can be used as a sponge or towel, for which purpose it is frequently sold in our stores. The chief value of the plant in this country is in this sponge-like fibre, and it is worth growing in for ornament; but I doubt if it will ever become prominent as a food-plant. The plant re-

^{*}Botanical synonyms of this species are the following, amongst others *Luffa Ægyptiaca*, *L. Petola*, *L. striata*, *L. Veitchii*.

quires a long season, and it should be started early and placed upon a warm quick soil. Like the cucumber and melon, the luffas are tender and should not be placed in the field until frosty weather has passed.

Sing-kwa. (*Luffa acutangula.*)

This plant differs from the preceding in bearing a ten-ribbed fruit, as shown in the illustration (below), and leaves which are rounded in outline and only slightly lobed. It is in common cultivation by the Chinese about New York, to whom it is known as *Sing-kwa*, or "hairy squash," although I do not know why the name is applied to it unless in reference to the somewhat pubes-



Sing-kwa.—*Luffa acutangula.*

cent stems, although it does not differ perceptibly in this respect from the *Sua-kwa* just described. This plant, like the other, is widely distributed in the tropics and is known under a variety of names. To botanists it is commonly known as *Luffa foetida*. We have grown it as Rag Gourd. The name Dish Cloth Gourd can be as well applied to it as to the other. The uses of the fruit are the same as those of *Sua-kwa*.

III. MISCELLANEOUS VEGETABLES.

Ga-lon-ow, or Chinese Pea. (*Pisum sativum.*)

The pea of the Chinese gardens behaves like a little improved or perhaps ancient type of the common pea. It is the same species as ours. It differs chiefly in having somewhat knotty or

constricted pods, as shown in the illustration (p. 198) The pods "shell" very hard, and there is a tendency to develop a broad border or margin along the lower side. The peas are small and are variable in color, and they generally turn dark in cooking. In quality, they are sweet and excellent, but they do not possess any superiority over our common varieties.

The seeds which we have obtained from the New York Chinamen are mixed. In color, the peas run from nearly white to dark brown. The brown seeds, however, have given us much earlier pickings than the light ones. In one instance, the seeds were sorted into three grades, light, medium light, and dark brown, and all were planted in sandy soil on the 20th of April. On the 5th of July, the dark-seeded plot gave a good picking, while the light-seeded, and even the medium plots, produced much taller plants and very few of the pods had begun to fill. The dark and medium-seeded plots produced plants with colored flowers,—the standard being rose-purple and the keel black-purple and splashed. The light-colored seeds, on the other hand, gave pure white flowers, larger leaves and broader pods. These facts are interesting in connection with the evolution of the garden pea and its relationship to the red-flowered field-pea.

Tou-kok, or Chinese Bean. (Dolichos sesquipedalis).

This is a pole bean with few-seeded pods of great length and which are eaten after the manner of the pods of string beans. The same species, but commonly a shorter-podded variety, is sold by our seedsmen as French Yard-Long Bean. This bean is native to South America, and is widely cultivated in warm countries. It requires a long season, but we have little difficulty in securing pods twenty inches long. These pods are very slender, and somewhat flattened and ridged, and the beans are often placed two inches apart. The beans are like those of the French Yard-Long,—small and oblong ($\frac{1}{2}$ inch or less long), cinnamon-brown, with a white black-bordered eye. Mr. Wah Hang tells me that the Chinese name of this bean signifies "very long plain October," a name which is applicable to length of pod and season of ripening. Burr,* in speaking of this species, mentions a "variety known as

*Garden vegetables, 287 (N. Y., 1866).



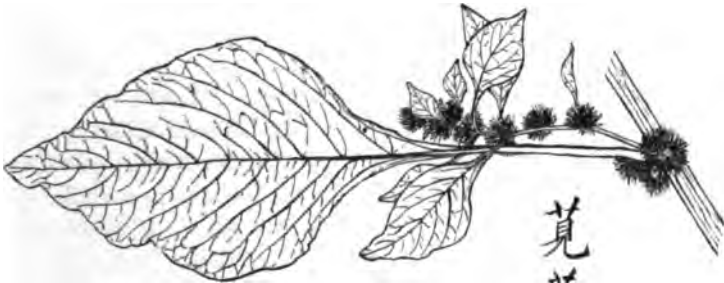
猪腸豇
即十月豇

Ga-lon-ou, or Chinese Pea. — Pisum sativum.

the Chinese Long-Pod," which "produces pods of much greater length, often measuring nearly three feet." I believe that this bean is well worth growing in American gardens, if one enjoys a late vegetable of the string-bean type.

Hon-toi-moi. (*Amarantus Gangeticus*).

This plant is used while young for greens. It is very closely allied to the common Beetweed or Pigweed, a plant which is similarly used in many parts of this country. The plant is widely cultivated in oriental countries and seems to be much prized. The



Leaf and flower-clusters of *Hon-toi-moi*.—*Amarantus Gangeticus*.

莧菜米

Chinaman of whom I procured seed parted with it reluctantly, saying that it was very choice. Yet I am unable to discover any unusual merit in the plant for American gardens. In the south, if introduced, it might become a weed, but it has not shown that tendency here. Our first sowing was made in 1891, and the ground has been much neglected since. It came up from self-sown seed in 1892, but it has not been seen since.

Yon-soi. (*Coriandrum sativum*).



THIS is coriander, the young leaves of which are relished as a condiment by the Chinese. I am not sure if this Chinese plant is identical with the plant of our gardens. Louriero, a botanist who wrote upon the flora of China over a century ago, mentions the plant, taking it to be the same as the European coriander. DeCandolle*, however,

* Prodromus, iv. 250.

expresses a doubt as to the identity of the two, but Hemsley, in his recent flora of China, regards them as the same. The Yon-soi, as we have grown it, has leaves rather more finely cut than the common coriander, and the flowers are somewhat different in appearance. But in horticultural value the two are not unlike.

SUMMARY.

Various garden vegetables have been introduced into this country by the Chinese, some of which are worthy a place in American gardens.

The best known, and perhaps the most valuable of these new vegetables, is the Pe-Tsai, or so-called Chinese cabbage. This plant bears a loose lettuce-like head of crisp leaves, which may be used in all the fashions in which cabbage is served. This plant requires a cool and moist soil in which to make its best growth. It is essentially an autumn vegetable.

The Chinese mustard is an excellent plant for greens and produces an enormous amount of herbage. Its culture demands the same attention as that advised for Pe-Tsai.

California Peppergrass appears to be a finely cut-leaved form of a mustard long known in old gardens, but not described either in American botanies or gardening books. It is one of the best of all plants for early spring greens. Although the species is cultivated in China and Japan, it does not appear to have been independently introduced from those countries in recent years. It is not known how or when the plant first came into this country.

Other mustard-like plants recently introduced from China are the Pak-Choi, used as greens and for the white thick leaf-stalks; and the Tuberous-Rooted Mustard, grown for its small turnip-like root. These plants possess less merit for American gardens than the foregoing species.

Of the various squash-like plants introduced by the Chinese, the best is probably the Wax Gourd or Zit-kwa. The fruit of this is excellent for conserves. The plant is of easy culture, but requires a long season.

The La-kwa or Momordica has more merit as a curiosity and

an ornamental vine than as an esculent, for American tastes. It is not new to the American seed trade.

The luffas or Dish Cloth Gourds of the gardens are of two species, which differ chiefly in the contour of the fruits. The commoner species in this country has ribless cylindrical fruits, but the one chiefly grown by the Chinese about New York has club-shaped ribbed fruits. These fruits are interesting to us chiefly as a curiosity and as yielding a sponge-like fiber which is useful for household purposes.

The Chinese pea has little to recommend it to American gardeners.

The Chinese bean or Tou-kok is no doubt a valuable vegetable for late home use.

The remaining Chinese vegetables here discussed—Hon-toi-moi and Yon-soi—have very little value for our gardens.

L. H. BAILEY.

50,679

N7
C89b

UNIV. OF MICH.

JAN 18 1909

Bulletin 68.

August, 1894.

Cornell University Agricultural Experiment Station.

HORTICULTURAL DIVISION.

The Cultivated Poplars;

WITH REMARKS UPON THE PLANTING
OF GROUNDS.



By L. H. BAILEY.

PUBLISHED BY THE UNIVERSITY.

ITHACA, N. Y.

1894.

ORGANIZATION.

BOARD OF CONTROL:

THE TRUSTEES OF THE UNIVERSITY.

STATION COUNCIL.

President, JACOB GOULD SCHURMAN.

Hon. A. D. WHITE,	-	-	-	-	Trustee of the University.
Hon. JOHN B. DUTCHER,	-	-	-	-	President State Agricultural Society.
Professor I. P. ROBERTS,	-	-	-	-	Agriculture.
Professor G. C. CALDWELL,	-	-	-	-	Chemistry.
Professor JAMES LAW,	-	-	-	-	Veterinary Science.
Professor A. N. PRENTISS,	-	-	-	-	Botany.
Professor J. H. COMSTOCK,	-	-	-	-	Entomology.
Professor L. H. BAILEY,	-	-	-	-	Horticulture.
Professor H. H. WING,	-	-	-	-	Dairy Husbandry.
Professor G. F. ATKINSON,	-	-	-	-	Cryptogamic Botany.

OFFICERS OF THE STATION.

I. P. ROBERTS,	-	-	-	-	Director.
E. L. WILLIAMS,	-	-	-	-	Treasurer.
H. W. SMITH,	-	-	-	-	Clerk.

ASSISTANTS.

M. V. SLINGERLAND,	-	-	-	-	Entomology.
GEO. C. WATSON,	-	-	-	-	Agriculture.
G. W. CAVANAUGH,	-	-	-	-	Chemistry.
E. G. LODEMAN,	-	-	-	-	Horticulture.

Office of the Director, 20 Morrill Hall.

Those desiring this Bulletin sent to friends will please send us the names of the parties.

BULLETINS OF 1894.

62. The Japanese Plums in North America.
63. Co-operative Test of Sugar Beets.
64. On Certain Grass-Eating Insects.
65. Tuberculosis in Relation to Animal Industry and Public Health.
66. Test of Cream Separators.
67. Some Recent Chinese Vegetables.
68. The Cultivated Poplars.

THE CULTIVATED POPLARS.

I. GENERAL REMARKS.

There has been little attempt in experiment station literature to discuss matters of ornamental gardening. The so-called practical problems connecting directly with bread-winning have necessarily and properly absorbed the energies of investigators. But the ornamentation of rural and suburban homes is quite as much within the province of experiment station work; and it should also be remembered that the growing of plants is itself an industry which enlists a vast amount of capital, and this nursery business has received little direct and explicit aid from experiment station publications. The present essay is undertaken for the double purpose of explaining certain fundamental principles in landscape gardening—a subject to which the poplars readily lend themselves—and of unraveling a web of difficulties respecting the species and varieties of poplars, into which the nursery catalogues seem to have fallen. An investigation of the botanical and horticultural features of the poplars has been assiduously prosecuted for upwards of two years, and the writer has had the free use of various nurseries and plantations in Western New York and the aid of botanists in many parts of the country. As a group, the poplars possess comparatively small value in landscape planting, but this very fact affords me the opportunity I seek to press home the fallacy of certain common practices amongst planters.

At the outset, I must be allowed to explain that landscape gardening is the embellishment of grounds in such fashion that they shall possess landscape or nature-like effects. This definition at once removes from our consideration all the formal effects of flower-beds and sheared trees, which, while useful at times, bear no closer relation to landscape gardening than a cup of paint bears to the fine art of painting. In other words, a landscape garden—and that should mean every country yard, however small or simple—should have in it the elements of a picture. It should appear to have one thought or feeling running through it all, and this is

a condition which is impossible when trees or bushes or flower-beds are scattered all over the place, for in such case one is attracted by these individual and detached objects and is not particularly impressed with the place as a whole or as a unit. Such a yard is a nursery. An artist would not care to paint such an area. If a yard is to be a picture, it must have a sense of frame-work about it,—certain strong groups of bushes or trees about the borders, and the central area should be a more or less open greensward with very cautious planting. The different parts are then in masses or in bold contrast, and the place has character. At the same time, the partial shutting off of the surrounding areas sets bounds to the place, defines it, and makes it to appear personal, snug and home-like. One should learn that it is not plants which make a place attractive, but the arrangement of plants. In fact, many otherwise attractive places are ruined by a wealth of good plants scattered without purpose over the lawn.

It is but a corollary of this discussion to say that plants which are simply odd or grotesque or unusual should be used with the greatest caution, for they introduce extraneous and jarring effects. They are little in sympathy with a true landscape garden. An artist would not care to paint an evergreen sheared into some grotesque shape. It is too formal and it has no elements of true beauty. It is simply curious, and shows what a man with plenty of time and long pruning shears can accomplish.

This leads me to one of the proper subjects of this paper, the planting of the Lombardy poplar. Fortunately, this tree is less planted in New York than in many western states. Its chief merits to the average planter are the quickness of its growth and the readiness with which it multiplies by cuttings. But in the north it is apt to be a short-lived tree and it suffers from storms, and it has few really useful qualities. It may be used to some advantage in windbreaks for peach orchards and other short-lived plantations, as explained in Bulletin 9 of this station; but after a few years a screen of Lombardies begins to fail and the habit of suckering from the root adds to its undesirable features. For shade, it has little merit, and for timber none. People like it because it is striking, and this, in an artistic sense, is its gravest fault. It is unlike anything else in our landscape, and does not

fit into our scenery well. The Lombardy should rarely, if ever, be seen as a single specimen ; and above all, its formality and stiffness should not be emphasized by planting it in rows along country roads. A row of Lombardies along a roadside is like a row of exclamation points !

But the tree can often be used to good effect as one factor in a group of trees, where its spire-like shape, towering above the surrounding foliage, may lend a spirited charm to the landscape. It combines well in such groups if it stands in visual nearness to chimneys or other tall formal objects. Then it gives a sort of architectural finish and spirit to a group of trees ; but the effect is generally lessened, if not altogether spoiled, if more than one Lombardy is in view. One or two specimens may often be used to give vigor to heavy plantations about low buildings, and the effect is generally best if they are seen beyond or at the rear of the building. Now and then one



Attractive Group of Lombardy Poplars.

sees a picturesque clump of Lombardies standing alone, like that shown upon page 207. Here the one original tree has given rise to a varied progeny of sprouts, and the mass has a freeness of outline which can never be obtained in a regularly planted clump of these trees from which the suckers are continually removed. This particular clump is one of the most picturesque objects in a sweeping landscape near Perry City, Schuyler County, N. Y., but its excellence is purely accidental.

Another feature of common ornamental planting which is well illustrated in the use of poplars, is the desire for plants simply because they grow rapidly. A very rapid-growing tree nearly always produces cheap effects. This is well illustrated in the common planting of willows and poplars about summer places on lake shores. Their effect is almost wholly one of cheapness and temporariness. There is little that suggests strength or durability in willows and poplars, and for this reason they should always be used as minor or secondary features in ornamental or home grounds. Where quick results are desired, nothing is better to plant than these trees, but better trees, like maples, oaks, or elms, should be planted with them and the poplars and willows should be removed as fast as the other species begin to afford protection. When the plantation finally assumes its permanent characters, a few of the remaining poplars and willows, judiciously left, may afford very excellent effects; but no one who has an artist's feeling would be content to construct the frame work of his place of these rapid-growing and soft-wooded trees.

I have said that the legitimate use of poplars in ornamental grounds is the production of minor or secondary effects. As a rule, they are less adapted to isolated planting as specimen trees than to use in composition,—that is, as parts of general groups of trees, where their characters will serve to break the monotony of heavier foliage. The poplars are gay trees, as a rule, especially those, like the aspens, which have a trembling foliage. Their leaves are bright and the tops are thin. A few of them in judicious positions give a place a sprightly air. I especially love the common aspen or *Populus tremuloides* of our woods (Fig. 14). Its light dancing foliage and silver-gray limbs always cheer me, and its autumn color is one of the purest golden-yellows of our land-

scapes. I like to see a tree of it standing out in front of a group of maples or evergreens. Its whole attitude is then one of familiarity.

The cottonwood is perhaps the best of all our poplars as a single specimen. It makes a noble tree, spreading its gray branches far and wide. But like the aspen, it is cheerful and restive. One is not moved to lie under it, as he is under a maple or an oak. Its leaves rustle with the lightest movement of air. The ripple of its foliage always recalls to my mind the play of wavelets upon a pebbly shore. The day is never so dark, but the cottonwood reflects a flood of light.

Some of the forms of the black poplar of Europe are especially satisfactory for the production of lively effects in planting. Of these, I know of none better than the form known to nurserymen as *Populus elegans*. It has a most pleasing light and tremulous foliage, the effect of which is heightened by a twiggy character of growth and a reddish cast to the leaf-stalks and young shoots. It is an elegant tree, and well adapted to planting in front of heavier foliage in the most conspicuous portion of the grounds.

Some of the silver or white-leaved poplars produce the most striking contrasts of foliage, especially if set near darker trees. Bolle's poplar (*Populus Bolleana* of the nurseries) is one of the best of these trees. Its habit is something like that of the Lombardy. The upper surface of the deeply lobed leaves is dark dull green, while the under surface is almost snowy white. Such emphatic trees as this should generally be partially obscured, by planting them in amongst other trees so that they appear to mix with the other foliage, or else they should be seen at some distance. Other varieties of the common white poplar or abele are occasionally useful, although most of them sprout badly and may become a nuisance. But the planting of these immodest trees is so likely to be overdone that I scarcely dare recommend them, although, when skilfully used, they may be made to produce most excellent effects. If any reader has a particular fondness for trees of this class (or any others with woolly-white foliage) and if he has only an ordinary farm-yard to ornament, let him reduce his desires to a single tree, and then if that tree is planted well on the inside of a group of other trees, no harm can result !

There are various weeping and grotesque horticultural varieties of the poplars, as of other trees. Concerning the use of these, I need only say that they are curiosities and that they should not be given prominent positions directly in front of the house. I think that no one will care to dispute me if I say that a person who fills his front yard with such specimens, has little appreciation of natural objects. A few grotesque specimens in positions of secondary importance may be desirable, as in a side or back yard, but one will find that the more he cultivates a love of natural scenery the less he cares for mere monstrosities.

I may seem to have placed myself in the position of writing a bulletin upon a group of trees which, upon the whole, I should be quite as willing to discourage as to augment; but my object has been rather more, as I intimated at the outset, to point out certain common defects in habits of thinking about ornamental trees, and to discourage the use of trees simply because they are odd, quick-growing and cheap. I wish that there were fewer Lombardy poplars in many parts of the country, fewer of the ugly white or silver poplars, and more of the American and European aspens, of the large-toothed aspen, of the cottonwood, and the Russian *Certinensis* poplar. Many of the species are excellent for covering sand-hills—for which the white poplar is well suited—or rough or waste places, and they are capable of adding much light and cheer to a yard. But planters are too prone to use certain ones over freely.

Poplars are often disagreeable upon the lawn because of the abundance of down or wool which they give to every breeze in May and June, when the seed-pods burst. There is really little occasion for this annoyance, however. The poplars are dioecious,—that is, the male and female flowers are upon different trees (although both sexes are rarely upon the same trees in the cottonwood). Nurserymen, therefore, should grow only the male specimens. The cuttings from a male tree—or one producing no cottony seeds—will give progeny of the same character. Of the Lombardy, there is only the male sex in the country, the female never having been introduced, or at least not distributed, so far as I know; while the weeping willow is represented only by the female plant. Some of the species and varieties are worth plant-

ing for the catkins which are produced so freely in early spring. The European aspen (*Populus Tremula*) is particularly desirable in this respect (Fig. 13); and this species also has a most interesting habit and foliage.

It should be said, in passing, that most of the poplars are hardy trees and thrive in a great variety of trying situations. This, together with the ease of propagation and their cheapness, combined with free and rapid growth, makes them the best of trees for nurse plantations,—that is, for temporary shelter for other trees and bushes. In this respect the common aspen poplar is one of the most valuable of all trees in the reforestation of American lands. It springs up quickly in clearings, and during its comparatively short life holds the soil and protects other vegetation and finally contributes its own substance to the maintenance of the stronger forests. In this manner it has exerted a most powerful effect upon the configuration of our forest areas and upon the fertility of the land from remote time. The same qualities make it valuable, in many instances, in extensive ornamental plantings.

The recent introduction of Russian poplars has added considerable confusion to nursery lists, and it was this fact which first led me to take up this inquiry. The chief merit of the Russian trees is for planting in the northwestern prairie states, but all of them are worth attention for exposed localities in this state, as well as for ornamental planting. I am convinced that the so-called *Populus Certinensis* (properly *P. laurifolia*) is one of the very best trees to plant where quick results are wanted and where some feeling of strength and durability is also desired. The best discussion of these Russian poplars which I know is contained in Bulletin No. 9 of the Minnesota Experiment Station by Professor S. B. Green, published in 1889. The following is a more recent sketch of these trees by the same author, prepared for this occasion :

" Russian Poplars in the Northwest.—In the arboretum of the Minnesota Experiment Station are 12 kinds of Russian poplars that were received from the Iowa Agricultural College. Most of them have been grown in our collection for seven years, and some of them have been tried for a much longer period in other parts

of Minnesota, in Iowa and the Dakotas, but not long enough anywhere in this country to warrant final conclusions. Those who live in locations naturally in timber can hardly understand the importance of the genus, to which these trees belong, to the pioneers on the wind swept prairies. The ease with which many of them are increased, their rapidity of growth, great hardiness against extremes of heat and cold, excessive moisture, and prolonged drouth, make them widely sought as pioneer trees in most severe locations, for the formation of wind-breaks and for shade from the scorching sun.

"I would not be understood as recommending the general planting of poplars where our finer deciduous trees readily succeed, but for a strong effect in the shortest time in severe locations they have no rival except the large growing willows, which may generally be used with them to advantage. Among the collection of poplars commonly referred to as of Russian origin, are trees having a great variety in growth and foliage, so that by the judicious use of them alone one can secure very good effects in landscape planting. They are not, however, and never have been, represented as new species, but as hardier forms of species already introduced into this country, and in the following notes I have grouped the kinds under the several heads where they evidently belong, using their nursery or horticultural names. Aside from the few exceptions noted, they are all easily increased from hard wood cuttings made in the fall or spring.

"ANGULATA CLASS—*Young growth plainly marked with ridges or angles.*

Dudley's Populus [properly *P. balsamifera*, var. *viminalis*]. Growth only moderate; when young rather upright in habit, but somewhat pendulous when old. Our older specimens have been badly injured by leaf rust in dry summers, and on this account I have ceased propagating it. The leaves are broadly lanceolate, very wavy on the edges and the young branches very angular.

"*P. betulifolia* is probably the same species as *P. nigra* of the eastern nurseries. It makes a tree that is rather open in habit, inclining to a straight trunk with branches coming out at nearly right angles. The foliage remains bright and fresh even in dry sod land in severe seasons. It is not especially valuable for tim-

ber but is interesting and useful for contrasting with other trees ; leaves very thick, very large and broadly deltoid, much larger and broader than leaves of the cottonwood under like conditions.

" *Wobsky Poplar*. One of the most distinct of its class ; of rapid growth and open regular habit. As a timber tree it is upright and valuable, but it seems to be more susceptible to the work of the poplar borer than other kinds and it occasionally loses its foliage in dry places. On account of these weaknesses it will not be largely planted in this section, but occasional trees may often be used to give variety. The leaves are large, ovate heart-shaped, stiff and very flat, of a shiny blue-green color on the upper and a light green on the lower side. Buds large and sticky. The young growth is only slightly angular.

" *P. Certinensis* [*P. laurifolia* of botanists] was introduced into this country and disseminated by Arnold Arboretum. It is perhaps the best of the collection for general prairie and ornamental planting in this section ; perfectly hardy even in the severest exposures and rarely, if ever, affected with leaf rust which so often checks the growth of the cottonwood. Its timber makes very good siding for buildings and floors, and answers many of the purposes for which pine is generally used. It does not warp or crack like our native cottonwood. It is rather upright in form, with thick leathery leaves and of very rapid growth. It does not grow quite as fast as the native cottonwood nor resist the attacks of the leaf beetle so successfully, but it is a much longer-lived tree and stands close planting very much better. It is grown readily from cuttings, which in our forest plantation made a growth of a trifle over 12 feet in three years from half-inch cuttings planted eight inches apart in rows eight feet asunder. The leaves are thick and leathery with a wavy edge. The new wood is strongly angular. [The form of leaf is shown in Figs. 7 and 8.]

" The *Populus Petrowski* so closely resembles *P. Certinensis* that I think them one and the same thing. Professor Budd obtained this in Russia and thinks it different from the latter. If this is true it does not show its characteristics until older than any specimen we have.

"The poplar known as *P. pyramidalis* var. *fastigiata* is evidently the Russian form of the Lombardy, if not the same thing. It has been introduced in the hope that it would prove hardier and longer lived than the common form, but in our experience of some seven years, young trees of either form have never been injured in this vicinity. It may, however, prove to be a longer lived tree than the common Lombardy, which is well known to be quite hardy, even in somewhat severe locations, when young, but to be very short lived on the dry prairies of the Northwest. It is, however, interesting to know that while the common Lombardy poplar is an almost worthless tree in most parts of Minnesota, yet near Duluth and along Lake Superior it is quite a success.

"**BALSAMIFERA CLASS.**—*With large sticky buds and young growths free from ridges or angles.*

"*Populus balsamifera* of Asia, as we have it, is probably the type of which *P. laurifolia* and *P. Sibirica* var. *pyramidalis* of horticulturists are but variations. The lamented Chas. Gibb said he saw in the botanical gardens at Kazan a specimen of this two feet in diameter and 50 feet high, and although it resembled *P. Sibirica* when young, it is quite different from it in form when old. Either of the next two kinds are preferable to it for planting, as the leaves of this have an unpleasant way of curling together.

"*P. Sibirica* var. *pyramidalis* [a form of *P. balsamifera*, var. *intermedia* of botanists], makes a fair growth and is desirable for ornamental planting. I think the foliage will endure more hardship than the *P. balsamifera*, to which it is similar in form.

"*P. laurifolia* [of horticulturists, but *P. balsamifera*, var. *intermedia* of botanists] is the best of this class. It is little slower growth than the *P. Certinensis* but like it healthy, vigorous and a good timber tree, and much superior to the cottonwood for lumber or fuel. Its thick leaves withstand the hottest, driest air of the West, either standing alone or in shelter belts. The leaves are thick and leathery, oval in form, a smooth clear white on the under side, and a bright clear green on the upper; generally flat, but sometimes a little folded.

"**WHITE POPLAR CLASS.**—The typical Russian form of this is rather more upright than the common white poplar and does not

sprout so much. This latter quality will be considered desirable by growers of occasional specimens. On the other hand, it is not so easily propagated as the common form and is perhaps, no harder, so that it will not supplant it for forest plantations where the beautiful white, fine-grained wood of this species is desired, and where the habit of sprouting from the roots is no drawback.

"*P. alba* var. *Bolleana* is very different from the common white



a b c d e f g h i i k l m n o

1. WINTER TWIGS OF POPLARS.—a, b, c, d, forms of *Populus grandidentata*; e, *P. angustifolia*; f, *P. nigra*, var. *elegans*; g, *P. balsamifera*, var. *latifolia* (*Noletii*); h, *P. nigra* (*Eugenie*); i, *P. monilifera*; j, *P. laurifolia* (*Certinensis*); k, *P. balsamifera*, var. *viminialis*; l, *P. nigra* (form known as *Canescens*); m, *P. alba*, var. *canescens*; n, *P. alba*, var. *nivea*; o, *P. alba*.

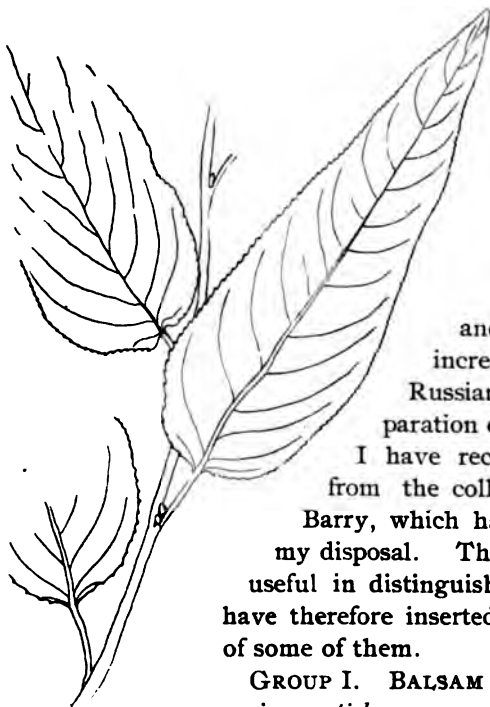
poplar, which it resembles in foliage and bark, but its leaves are nearly as deeply lobed as those of the common silver maple; on the upper side they are of a rich dark green color, while on the lower side they have a very heavy coat of white down. Its growth when young is nearly as upright as the Lombardy poplar with a tendency to a globular formed head when old. It is, however, a long lived tree even in severely dry sections in the West, where the Lombardy poplar is worthless. It is of rather moderate or slow growth. I find it much more difficult to propagate than most other poplars, but have had fairly good success with cuttings taken off in the fall, and well callused before planting

in the spring, in the same manner as practiced with grape cuttings in the West. It grafts readily on several of our common poplars and on strong growing kinds its growth is considerably increased.

"*P. alba* var. *argentea* closely resembles the species but has heavier down on the underside, and is rather more spreading in habit, and is more easily propagated from cuttings."

II. THE CULTIVATED SPECIES OF POPLARS.

The following catalogue attempts to refer the nursery and horti-



cultural names of poplars to their proper botanical species, and it includes various notes upon the horticultural values of the different types. The genus appears to be

much confused

amongst nurserymen,

and the perplexity has been

increased by the arrival of the

Russian varieties. In the pre-

paration of this monographic list,

I have received the greatest aid

from the collection of Ellwanger &

Barry, which has been freely placed at

my disposal. The winter twigs are often

useful in distinguishing the species, and I

have therefore inserted a photograph (Fig. 1)

of some of them.

GROUP I. BALSAM POPLARS, or those with

resinous-sticky more or less elongated buds.

1. **Populus angustifolia** (James, Long's Exped. i. 497). YELLOW or BLACK POPLAR of the west. Fig. 2. A pyramidal small tree with ovate-lanceolate willow-like leaves and cylindrical twigs, native from South Dakota west and south. It is sparingly cultivated. It is a tree of good habit and soft clear green
2. *Populus angustifolia*. ($\frac{1}{2}$ nat. size.)

foliage, and is worth attention in the composition of groups. May be confounded with *Populus balsamifera*, var. *viminalis*, which see. The slender, cylindrical winter twigs with small buds (e, fig. 1) are very different from the heavier and angled shoots, with coarse buds, of the other (k, fig. 1).

2. ***Populus balsamifera*** (Linnæus, Sp. Pl. 1034 (1753). BALSAM POPLAR, ТАСМАНАС. Fig. 3. A tall upright tree, with a narrow straight top, growing in woods and along streams in the Northernmost States, and also in Northern Europe and Asia. Leaves thick and firm, erect, whitened beneath, usually smaller than in most other poplars of this Group: in shape ovate-lanceolate or oval, tapering towards the top and sometimes at the base, finely and obtusely toothed. Young branches nearly or quite cylindrical.



3. *Populus balsamifera* (16 Voronesh.) ($\frac{1}{2}$ nat. size.)

The native form is occasionally seen about farm buildings and roadsides, where it makes a durable and pleasant tree; but it is most too stiff for the pleasantest effects and too narrow for the best shade. The dull whiteness of the under side of the leaves affords a pleasant variety and contrast in its foliage, and the fragrance of the resinous buds in spring is pleasant to most persons. It is a desirable tree for occasional planting, but, like the Lombardy, it generally appears to best advantage when placed amongst other trees. It is a hardier tree than the Lombardy, and does not run quickly to such extravagant heights. In cultivation from Russian sources, it is known as Nos. 16 and 26 Voronesh and 32 Riga. Fig. 3 shows ordinary foliage (16 Voronesh) about half size.

The balsam poplar is probably the most variable of poplars.

In cultivation in this country it is represented by no less than three well marked botanical varieties, differing from the species and from each other in the habit of growth, shape and color of leaves and character of twigs.

P. balsamifera variety **intermedia** (Loudon, Encyc. of Trees and Shrubs, 830 (1842). *P. laurifolia* of American horticulturists, not of botanists. *P. Sibirica pyramidalis*, of horticulturists).



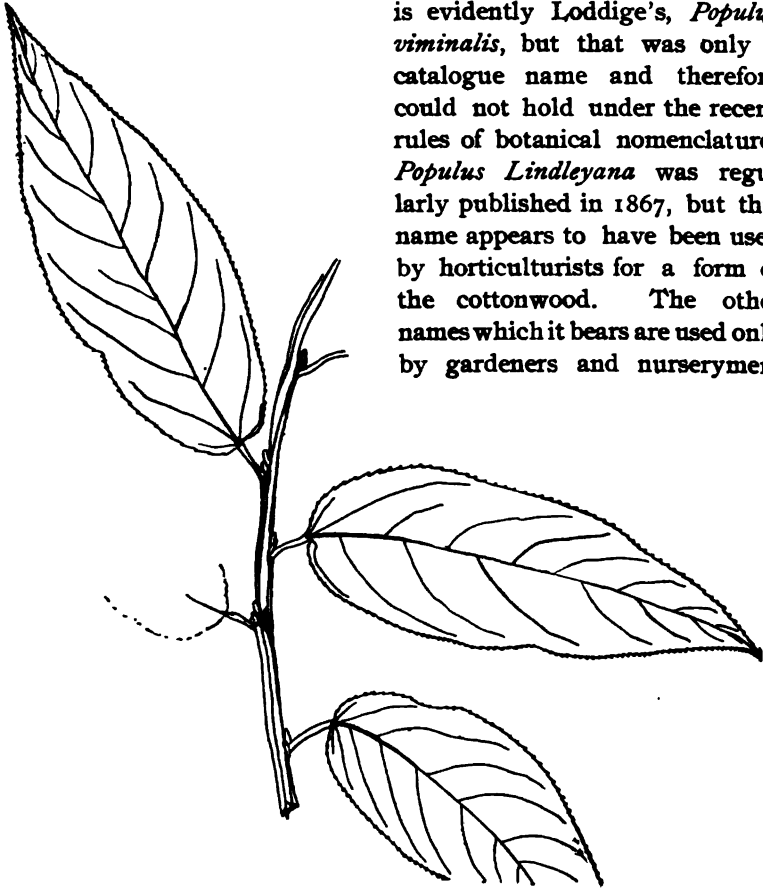
4. *Populus balsamifera* variety *intermedia*. $\frac{2}{3}$ nat. size. serrate, oval in outline, and

Fig. 4. A comparatively slow growing tree of close upright habit, from Northern Europe, where it is used as a street tree. The leaves are very thick and hard, finely

prominently whitened beneath, and they are commonly rather small for this group. Twigs hard and cylindrical. It is considered to be a valuable tree for hot and dry interior climates; and it also has distinct merit for ornamental planting. It eventually becomes a large tree. The *Populus laurifolia* and *P. Sibirica pyramidalis* of American nurserymen are, so far as I can determine, only minor variations of one varietal type. All these trees are amongst the recent introductions of Russian poplars.

P. balsamifera var. **viminialis**, (Loudon, Encyc. 830, t. 1510. *P. viminalis*, Lodd. Cat. (1836). *P. Lindleyana*, Booth, Rev. Hort. 1867, 380. *P. salicifolia*, *P. crispa*, *P. Dudleyi*, and *P. pyramidalis suaveolens* of horticulturists. Also sometimes called *P. laurifolia*). Fig. 5. A tree of only moderate and rather slender growth, with a partial weeping habit when old; native to northern Europe. It is at once distinguished from other forms of *Populus balsamifera* by its sharply angled twigs (k, fig. 1), and broad-lanceolate willow-like leaves which are finely serrate and often crinkled-margined.

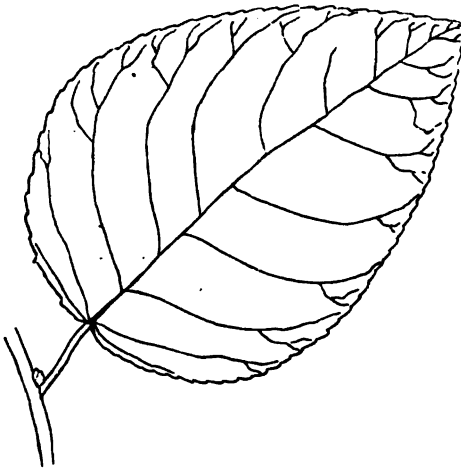
I am inclined to regard this as a distinct species from the balsam poplar. If it should be elevated to specific rank, it would be difficult to determine a correct name for it. Its first specific name is evidently Loddige's, *Populus viminalis*, but that was only a catalogue name and therefore could not hold under the recent rules of botanical nomenclature. *Populus Lindleyana* was regularly published in 1867, but this name appears to have been used by horticulturists for a form of the cottonwood. The other names which it bears are used only by gardeners and nurserymen.



4. *Populus balsamifera* var. *viminalis*. ($\frac{1}{2}$ nat. size.)

But however much doubt may attach to the botanical position of this small tree, it is valuable to planters if a tree of willow-like aspect but with more pronounced color effects and greater size and durability is desired. It is very like the native *Populus angustifolia*, which it represents in Europe, but is readily distinguished by its angled or furrowed stems, and less tapering and

crisped leaves which are conspicuously finely reticulated and whitened beneath. The color of its foliage is a grayish green, and in this respect it affords a contrast to the native species. The native seems to be rather the better tree of the two, although the *viminalis* has a more striking appearance.



6. *Populus balsamifera* var. *latifolia*. ($\frac{1}{2}$ nat. size.)

P. balsamifera*, var. *latifolia (Loudon, Encyc. 830. *P. Nolestii* and *P. Wobsky* of horticulturists). Fig. 6.—This variety includes Asiatic forms with ovate or cordate-ovate rather blunt pointed leaves, cylindrical twigs (or slightly ridged on strong shoots) (g, fig. 1) and the general habit of the balsam poplar. The leaves are usually large and thick, shining green above and dull white beneath, in shape and texture some-

what like the next species (*P. candicans*). The *Nolestii* poplar is now sold by Eastern nurserymen as an ornamental tree. Its strong habit and dark foliage adapt it admirably to planting near the rear borders of grounds. The *Wobsky* poplar is one of the recent Russian introductions, with somewhat the habit of a cherry tree, and is much prized in the northwest. The *Rasumovskoe* poplar appears to be of the same type.

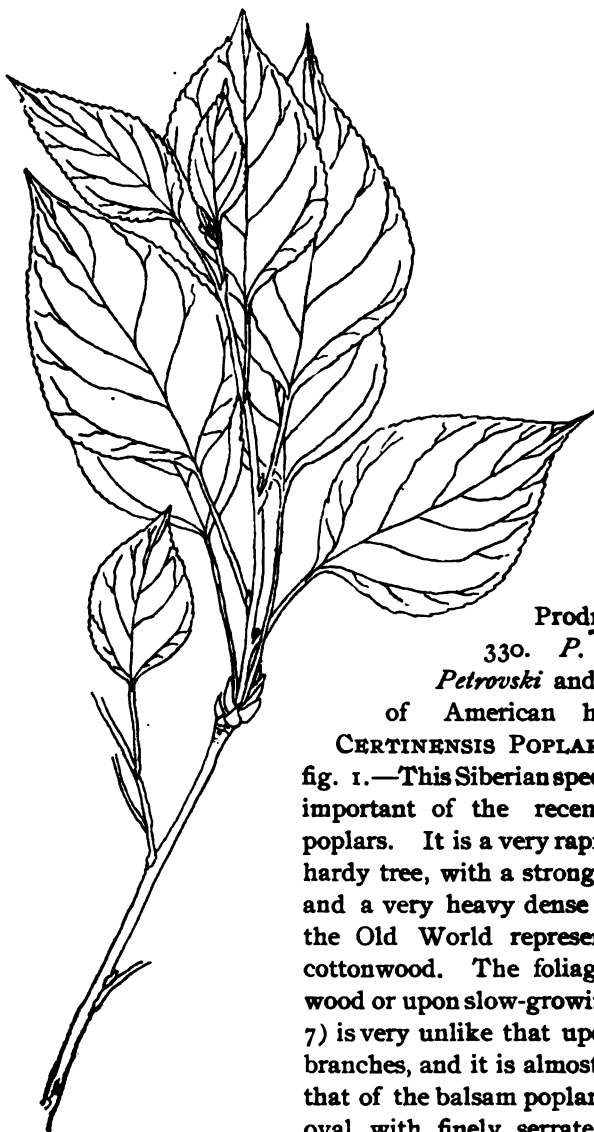
3. ***Populus candicans*** (Aiton, Hort. Kew. iii. 406. *P. balsamifera*, var. *candicans*, Gray, Manual, 2nd ed. 419. *P. Ontariensis* and *P. macrophylla* of European horticulturists). BALM OF GILEAD. Fig. on title page.—A strong-growing spreading native tree, frequently planted, and esteemed for its vigor and hardiness and the resinous fragrance of its large buds in spring-time. The leaves are broad and heart-shaped, green above and veiny and rusty-white beneath, and the leaf-stalk is usually hairy and somewhat

flattened. It is very different from the balsam poplar in method of growth, as it has none of the pyramidal or spire-like tendency of that species, but usually makes a broad and irregularly spreading top. While the tree is common in cultivation, it is rare wild. In the early days, however, it was found in very large trees in Michigan and other western states, and was used for sawing timber; and isolated natural groves of it are still occasionally seen.* The balm of gilead makes a good street tree, and is perhaps the best of the poplars for shade. Well grown trees have the darkest and richest foliage of any common poplar, and this character makes the tree valuable in heavy groups about the borders of a place. The top is liable to become open and broken with age, however, and the tree often sprouts profusely. It is not well adapted to smoky and dusty locations, as it soon becomes grimy. It was used to good purpose in the lagoon borders of the World's Fair, where its exuberant growth and stiff heavy leaves gave a massive effect. The illustration upon the title-page shows a spray of the balm of gilead, one-third natural size.

4. **Populus Simonii** (Carrière, Rev. Hort. 1867, 360).—A strong strict tree from China, whence it was introduced into France about 1861 by M. E. Simon. It is now very sparingly planted in this country, but its merits are scarcely known. In foliage it is much like the next species (*P. laurifolia*). Its leaves differ from those of the balm of gilead in having a rounded or tapering base and much finer teeth, but otherwise they are much alike. The shoots are reddish brown and spotted, and deeply grooved. Professor Craig, of the Central Experimental Farm, Ottawa, Ontario, who has had considerable experience with the tree, writes as follows concerning it:

"The tree in nursery and on the lawn is a very strong grower, with large ovate leaves, having the characteristic five-sided shoots of these Russian poplars. It grows very rapidly, making a growth of from six to ten feet per annum. I have not known it to winter kill either here or in Manitoba. It can hardly be termed strikingly ornamental, but is useful for planting

* Botanical Gazette, v. 91.



7. *Populus laurifolia* (or *P. Certinensis*). Slow-growing shoot. ($\frac{2}{3}$ nat. size.)

where wind-breaks are desired quickly. Like the Carolina poplar, it has a strong upright habit of growth."

5. **Populus laurifolia** (Ledebour *Icones Plantarum Nov. Ross.* v. 23, t. 479 (1834). *P. balsamifera*, var. *laurifolia*; Wessm., D. C.

Prodr. xvi. part ii.

330. *P. Certinensis*, *P.*

Petrovski and *P. Bereolensis* of American horticulturists).

CERTINENSIS POPLAR, Figs. 7, 8; j. fig. 1.—This Siberian species is the most important of the recently introduced poplars. It is a very rapid-growing and hardy tree, with a strong central leader, and a very heavy dense foliage. It is the Old World representative of our cottonwood. The foliage upon the old wood or upon slow-growing shoots (Fig. 7) is very unlike that upon the vigorous branches, and it is almost identical with that of the balsam poplar, being broadly oval, with finely serrate margins, and whitish beneath. The twigs, also, are cylindrical. But the strong shoots are

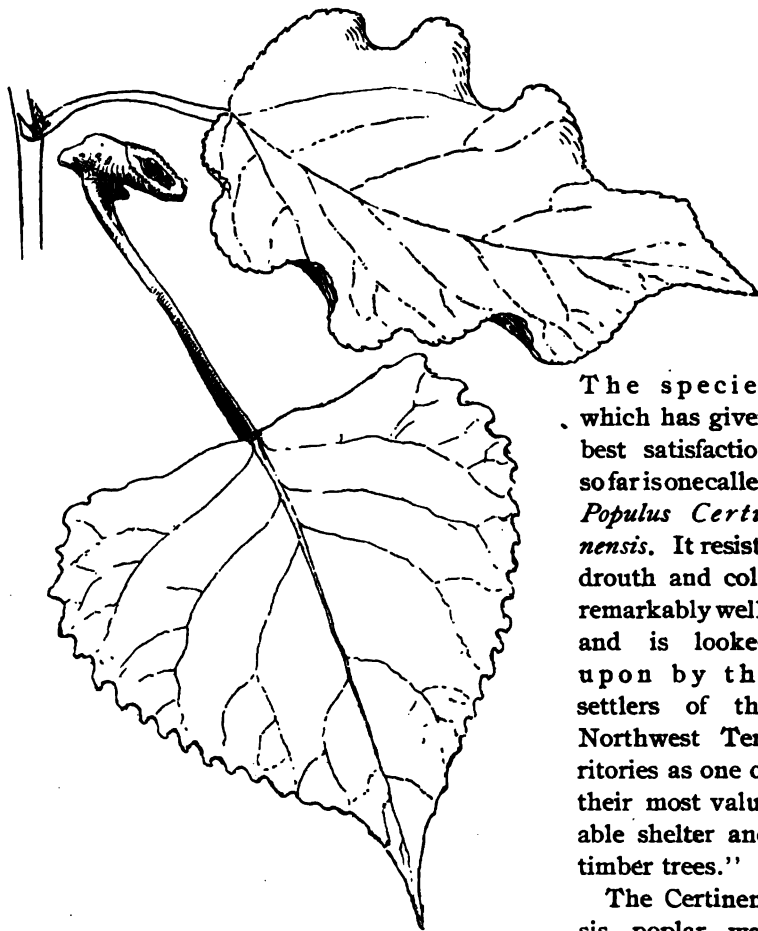
strongly angled or grooved and the foliage is much like that of the native cottonwood but darker ; and the growth is more close and erect. The sketch in Fig. 8 distinguishes the leaves perfectly, however :

<i>P. laurifolia</i> or Certinensis (upper leaf). Leaves broad-ovate in outline, with a rounded or tapering base and rather short point at the apex ; the margin rather closely toothed, wavy ; leaf-stalk comparatively short, only moderately flattened, glandless at the top ; stipules present and conspicuous. Bud long. Shoots slightly hairy.	<i>P. monilifera</i> or Cottonwood (lower leaf). Leaves triangular-ovate in outline, with a straight or truncate base and a long point at the apex ; margin coarsely scallop-toothed, plane ; leaf-stalk long, much flattened beneath the blade of the leaf, and commonly bearing two or three gland-like bodies at its top ; stipules absent or minute (falling early). Bud shorter. Shoots glabrous.
--	--

I imagine that the similarity of the Certinensis poplar and cottonwood has been the means of confusing them, for I have poplars under the names of *P. laurifolia* and Riga No. 40, which are cottonwoods. Whether these were really introduced from Russia after having first been introduced there from America, or whether the confusion is a mixing in our own plantations, I am unable to say. The Certinensis poplar is a more rugged tree than the cottonwood, with healthier foliage in the presence of leaf-rust, and its wood is said to be valuable. It is now much planted in the Northwest, and deserves to be more widely distributed.

Its effect in the landscape is considerably unlike that of the cottonwood. Its leaves out stand more horizontally, while those of the cottonwood hang loosely and often vertically and therefore give the tree top a heavier look. The terminal spray of the two is particularly distinguishable in this regard. The leaves of Certinensis upon the strong erect shoots stand almost squarely at right angles with the shoot, and, at some distance, therefore present only their ruffled edges to the eye, producing a most unique and picturesque effect. But on the whole, at least for the present, I should consider the cottonwood the better tree for ornamental planting in this state.

Professor Craig, of Ottawa, writes of the species: "I have been sending out cuttings of these so-called Russian poplars to Manitoba and the Northwest Territories for the past four years.



The species which has given best satisfaction so far is one called *Populus Certinensis*. It resists drouth and cold remarkably well, and is looked upon by the settlers of the Northwest Territories as one of their most valuable shelter and timber trees."

8. *Certinensis poplar* (above), and *Cottonwood* (below).
($\frac{1}{2}$ nat. size.)

The Certinensis poplar was used in the lagoon plantations

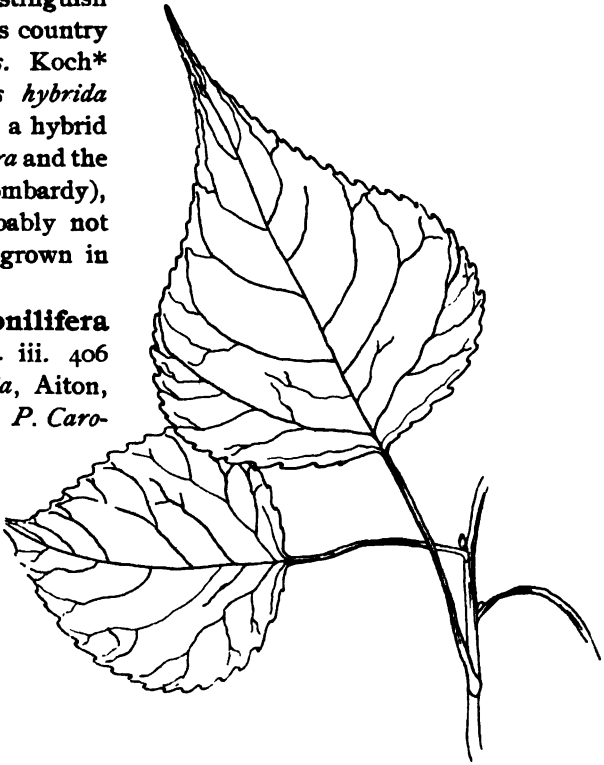
at the World's Fair, but because of its rapid growth in the direction of its leader, it made a less picturesque small tree than either the cottonwood or balm of gilead, which were similarly planted.

The name *laurifolia*, or "laurel-leaved," is generally applied in this country to another plant,—*Populus balsamifera*, var. *intermedia*. The name originated with the Russian botanist Ledebour, and he published a good illustration of the tree he had in mind and it is an admirable portrait of the large and crinkly leaves of the tree which in this country goes under the name of *Populus Certinensis*,—a name which, so far as I can learn, is simply a garden or nursery name. No. 39 Riga, as I have it, is the same. Neither am I able to distinguish the tree grown in this country as *Populus Bereolensis*. Koch* mentions a *Populus hybrida Berolinensis* as being a hybrid between *P. balsamifera* and the Italian poplar (or Lombardy), but his tree is probably not the same as the one grown in this country.

6. ***Populus monilifera***

(Aiton, Hort. Kew. iii. 406 (1789). *P. angulata*, Aiton, Hort. Kew. iii. 407. *P. Carolinensis*, Moench, Verzeichniss Weissenstein, 81 (1785: Catalogue name). *P. glandulosa*, Moench, Methodus, 339 (1794). *P. Canadensis*, Michx. f. Hist. Arb. Am. iii. 302, t. 12. *P. Carolina* of nurserymen).

9. *Populus monilifera*, unusual form. ($\frac{1}{2}$ nat. size.)



COTTONWOOD, CAROLINA and CANADIAN POPLAR. Fig. 8, 9; i, fig. 1. A strong growing handsome tree of large size, ranging from

* Dendrologie. ii. iA, 497.

western New England to Florida and the Rocky Mountains. Its leaf characters are sufficiently outlined above (under *P. laurifolia*), but it is variable in shape and color of leaves. Some of the forms are fairly distinct in foliage and aspect, and they appear to be associated with particular horticultural names, in the nurseries. Fig. 9 shows a form with very long-pointed and round-based leaves; but it usually bears, also, the typical triangular foliage. Some of the most ornamental specimens of cottonwood are those which have reddish leaf-stalks and midribs.

Taking all things into consideration, the cottonwood is probably the best of the poplars for general ornamental planting. It grows rapidly and in almost every soil, and yet it possesses an air of strength and durability which most of the poplars lack. Its foliage is always bright and glossy, and the constant movement of the broad rich green leaves gives it an air of cheeriness which few trees possess. The tree has been much used upon the western prairies and in western towns, much too abundantly for good landscape effects. The rapid growth of the tree gives a feeling of luxuriance to plantations, even when most other trees appear to be weak or starved. The cottonwood thrives best upon rather low lands, and yet it is generally an admirable tree upon high and dry areas.

The so-called Carolina poplar is only a very luxuriant cultivated form of the cottonwood. As sold by the New York nurserymen it does not differ otherwise from the wild *Populus monilifera* of our woods and creek borders.

There is a golden-leaved form of the cottonwood known as variety *Van Geertii* or var. *aurea*. It is one of the best of yellow-leaved trees, and generally holds its color throughout the season. Like all trees of this unusual character, it should be used cautiously, and the best effects are obtained when it is planted against a group of trees so as to appear as if naturally projecting from the other foliage.

7. ***Populus nigra*** (Linn. Sp. Pl. 1034 (1753). *P. Hudsonica*, Michx. f. Hist. Arb. Amer. iii. t. 10. *P. betulifolia*, Pursh, Fl. Amer. Sept. ii. 619. *P. Eugenie* of nurserymen). BLACK POP-LAR. h and l, fig. 1. A European tree of medium to large size, with leaves somewhat resembling those of the cottonwood, but

generally smaller and much less deeply toothed, shorter in proportion to their width and often with a tapering or rounded base. The tree usually has a pyramidal habit of growth and a dark cast to the foliage. The leaf-stalk is flattened, so that the foliage moves freely in the wind. It is a less lustrous tree than the cottonwood and grows more slowly. Specimens were found escaped along the Hudson by Michaux, who thought it an American species and published it early in the century as *Populus Hudsonica*. Pursh in 1814 published it again as the "birch-leaved poplar," *Populus betulifolia*, from trees found upon Lake Ontario. Although it was found half wild in New York about a century ago, it does not seem to have increased itself in America, for it is rarely seen, even in cultivated ground. The tree known in the West as *Populus betulifolia* is only a robust form of the European *P. nigra*.

The black poplar runs into many perplexing forms. The best which I know is var. *elegans* (*Populus elegans* of nurserymen. f, fig. 1). It is a tree of pronounced strict or pyramidal habit, but considerably broader than the Lombardy. The foliage is small and light colored and very versatile in a breeze, with a handsome reddish tint to the leaf-stalks and young shoots. It is worth growing in every well kept place, especially if placed against a planting of heavier foliage. *Populus canescens* of some American nurserymen is very like this, although it has less color and brightness.

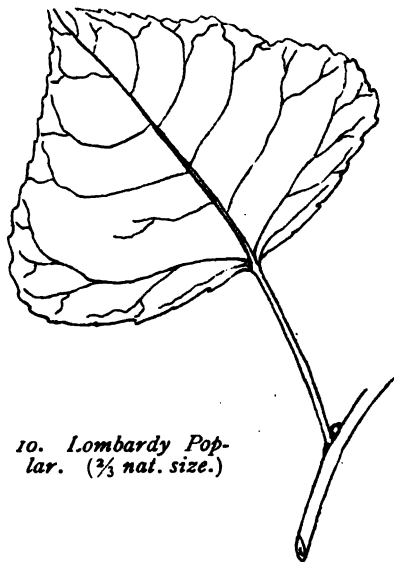
P. nigra, var. *Italica* (Du Roi, Harbkesche Baumz. ii. 141 (1772). Var. *pyramidalis*, Spach, Ann. Sci. Nat. 2nd ser. xv. 31 (1841). *P. Italica*, Moench, Verzeichniss Weissenstein, 79 (1785). *P. dilatata*, Aiton, Hort. Kew. iii. 406 (1789). *P. fastigiata*, Desf. Hist. Arb. ii. 265 (1809). *P. pyramidalis*, Rozier, Dict. d'Agric. vii. 619. *P. pyramidata*, *P. Pannonica*, *P. Polonica* of horticulturists). **LOMBARDY** or **ITALIAN POPLAR**. This tree is too familiar to need description. It differs from the typical black poplar (*P. nigra*) in its tall narrow growth, glabrous young shoots, a confirmed habit of suckering from the root and generally a more tapering base to the leaves. It is one of the characteristic trees of parts of Italy, and it is from one of the Italian provinces, Lombardy, that its common name is derived. The tree is probably native in Asia, however.

The Lombardy poplar was much prized in this country a hundred years ago. John Kenrick established a commercial nursery of ornamental trees in Newton, Massachusetts, in 1797, and two acres were "devoted to the cultivation of the Lombardy poplar, which was about the only ornamental tree for which there was any demand in those days."* It is probable that very few, if any, of the trees sold by Kenrick are still living, even in locali-

ties where the climate is not severe; and this is evidence that the tree is short lived—a fact which all careful observers must have noticed.

A hardy type of the Lombardy is grown in the Northwest. Professor Budd gives the following account of it.†

"In the summer of 1882 Mr. Gibb and the writer were surprised to find the Lombardy poplar in perfect health in central Russia, where our American black locust, honey locust and other trees killed down each winter as does the common peach in



10. Lombardy Poplar. ($\frac{2}{3}$ nat. size.)

north Iowa. Our surprise came from the fact that Loudon inclined to the belief that *Populus dilatata* [one name for the Lombardy Poplar] was native to the valley of the Po in Lombardy, from whence it came to England and America. But Russian botanists soon assured us that its home was in the east and that its hardiness varied like other species, and hence depended on the region from whence it was obtained. Under the name of *Populus dilatata* we imported the hardy kind from Voronesh, in central Russia. As this is 300 miles north of the sea of Azoff, from whence came the Russian Mennonites of Minnesota, I suspect

*Garden and Forest, i. 302.

†Rural Life, Aug. 31, 1893, p. 12.

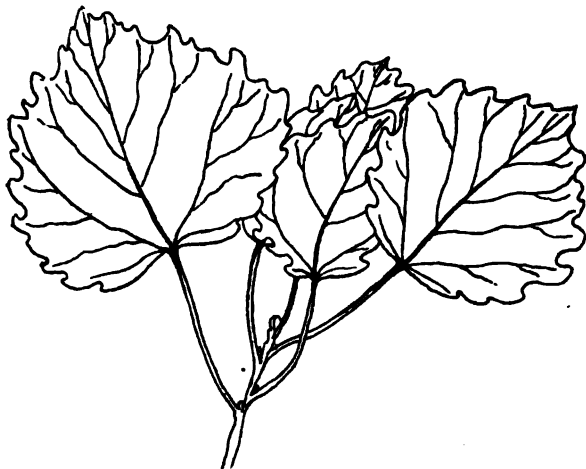
that our importation is harder than the one seen around St. Paul. We call it the Russian Lombardy. It is a much nobler tree than the variety from the Po valley, as its top is not so thin and spiry, and its foliage is thicker and darker. We have not talked about this poplar for the reason that its timber has no relative value. Yet it fills a place in landscape gardening not taken by any other tree."

The various merits of the Lombardy poplar—which is the most familiar tree of the genus—have been already discussed. It has been planted too freely, but it is gradually dying out in the east, and time will no doubt eliminate its offensiveness in the landscape. There is said to be a form of the Lombardy with variegated leaves, but I hope that it will not find its way into this country. A tree which is already over-bold would be impertinent with a painted foliage. "Planted as it was a hundred, or even fifty years ago, in all possible situations, without regard to its surroundings or to the positions in which it was placed, it did more, perhaps," says *Garden and Forest*, "than any tree which has ever been planted, especially in some parts of Europe, to disfigure the landscape. There is no tree, however, which can take its place, or which can so quickly send up a tall, slender shaft to break a low or monotonous sky line. It became an unpleasant feature in the landscape only when it was used without judgment and without discretion."

GROUP II. ASPENS and WHITE POPLARS, *with short non-glutinous often pubescent buds.*

8. **Populus Tremula** (Linnaeus, Sp. Pl. 1034). EUROPEAN ASPEN. Figs. 11, 13.—An open-headed, light-leaved tree, common throughout Europe, and occasionally cultivated in this country, especially in its weeping form. Leaves small and thin round-oval, more or less whitened beneath, especially when young, bordered with deep and rounded incurved teeth. Leaf buds small. The leaf-stalks are long and slender and flattened, giving a restless motion to the foliage.

The weeping form of the European aspen is perhaps the best weeping tree amongst the poplars. The spray is light, airy, and fountain-like, quite unlike the more common weeping forms of our native *Populus grandidentata*, which present a stiff weeping aspect, a combination which is rarely pleasing. The lightness



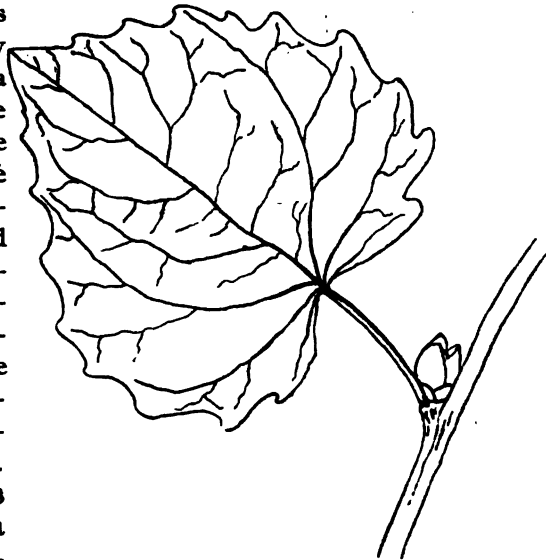
11. *Populus Tremula* ($\frac{1}{2}$ nat. size).

of the foliage of the European aspen has been remarked by writers from the earliest times. Gerard, in 1597, remarks that the tree "may also be called Tremble, after the French name, considering it is the

matter whereof womens tongues were made, (as the Poets and some others report) which seldome cease wagging."

A characteristic interest attaching to this tree is the profusion of very long catkins which appear in earliest spring, even before our native poplars are in bloom. They appear at Ithaca late in March or the first of April. The staminate or male catkins are particularly pleasing, and planters should select that sex, if possible. The illustration on the next page shows these interesting flower-clusters nearly full size.

9. *Populus grandidentata*
(Michaux, Fl. Bor.-



12. *Populus grandidentata*. ($\frac{1}{2}$ nat. size.)

12 The Staminate or male catkins of the European Aspen, appearing in earliest spring.



Am. ii. 243(1803). *P. Græca pendula*, *P. nigra pendula* and *Parasol de St. Julien* of nurserymen). LARGE-TOOTHED ASPEN. Fig. 12; a, b, c, d, fig. 1.—This is a common native tree from Nova Scotia to North Carolina. It is distinguished from the European aspen, above, by much larger and thicker leaves which are bluish or rusty-white beneath, more ovate in outline, with larger and more spreading teeth, stouter leaf-stalks and larger leaf-buds. In its

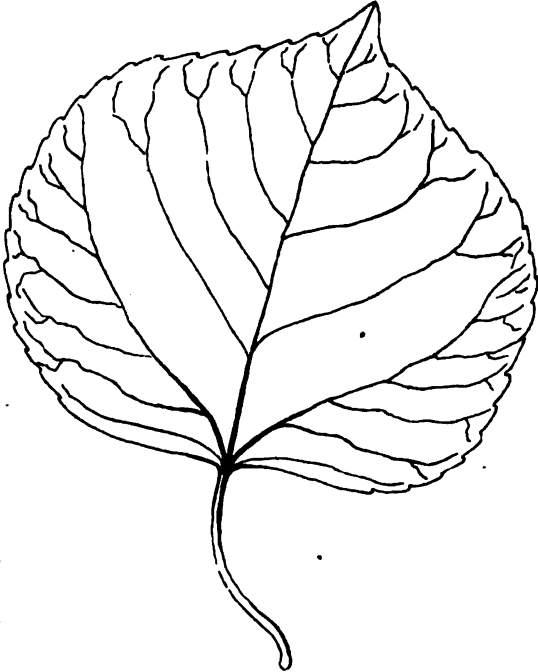


14. *Populus tremuloides* ($\frac{2}{3}$ nat. size).

normal or erect form, it is rarely cultivated, but the weeping varieties, under a variety of names, are frequently seen. Most, and perhaps all of these varieties originated in Europe, where the tree, like the cottonwood and the common aspen, were early introduced. The habit of the tree is too stiff and the foliage most too heavy to make the best weeping subjects, however. One of the best of these weeping forms is that known as *Parasol de St. Julien*. The characteristic weak or zigzag winter twigs of the weeping varieties of this species are shown in Fig. 1. A is the form sold as *P. grandidentata pendula*; b is *Parasol de St. Julien*, and this twig shows a flower-bud midway. These two forms, it will be seen, have a stiffer or straighter habit than the two following. C is the form sold as *P. Græca pendula*, and d the one called *P. nigra pendula*.

10. **Populus tremuloides** (Michaux, Fl. Bor.-Am. ii. 243 (1803). *P. trepida*, Willd. Sp. Pl. iv. 803. *P. Græca* and *P. Atheniensis* of horticulturists). COMMON ASPEN or POPPLE. Fig. 14.—This is the commonest of the American poplars, and it ranges from Labrador to Kentucky, New Mexico and California.

It is the species which springs up in recent clearings. In aspect it is much like the European Aspen (*P. Tremula*), but the leaves lack entirely the deep teeth of that species and they are green on the under side. The catkins are also smaller, and there are other botanical differences. There are no horticultural varieties of this species, so far as I know; but the plant is worthy attention from planters, as already indicated (page 208).

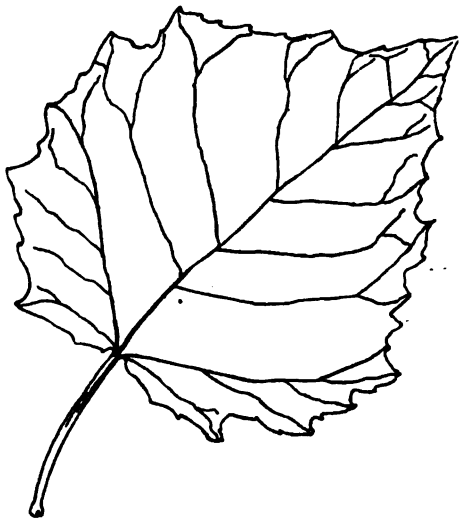


15. *Populus Sieboldi* ($\frac{1}{2}$ nat. size).

11. **Populus Sieboldi** (Miquel, Ann. Mus. Bot. Lugd. iii. 29. *P. rotundifolia* of American nurserymen). Fig. 15. A Japanese species with foliage somewhat like the last only much larger and whitish below. Professor Sargent says* that "this tree is not rare in southern Yezo, where it grows to the height of twenty or thirty feet, springing up in considerable numbers on dry, gravelly soil." The species is little known in this country. It makes a tree of spreading habit, with rather dark and heavy foliage. It appears to be hardy in western New York.

*Garden and Forest, vi. 404.

12. **Populus alba** (Linnæus, Sp. Pl. 1034 (1753). WHITE POPLAR, ABELE. A common European tree frequently planted in this country. Leaves much like those of *Populus grandidentata*, but smaller, usually thicker and more angular, the under surface—especially early in the season—woolly white. The straight, strong cylindrical winter shoots of this species and its



16. *Populus alba* var. *canescens* ($\frac{2}{3}$ nat. size).

varieties, with the very small buds, are shown at o, n, and m, in fig. 1.

The typical form of *Populus alba* is less grown here than the varieties with lobed and very white-bottomed (and occasionally variegated) leaves.

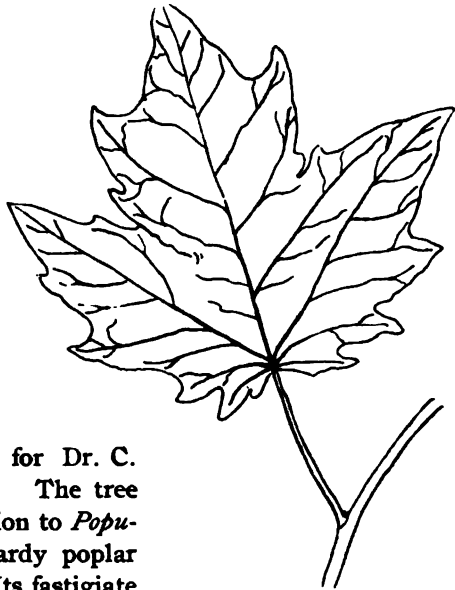
P. alba, var. **nivea** (Wesmael, DC. Prodr. xvi. 2d part, 324. *P. nivea*, Willd. *P. argentea* of nurserymen). This is the commonest form of white poplar in this country. It is known by the

snow-white under surfaces of its foliage and the three or five lobed maple-like leaves. It is far too frequent about old yards, where its inveterate brood of suckers make it a perpetual nuisance. It is sometimes called Silver maple, from the resemblance of its foliage to that of the maple. The tree is so obtrusive in its character that it can rarely be used with good effect in home grounds. As a street tree in cities it is particularly offensive for the cottony covering of the under side of the leaves and of the shoots holds soot and dust, and it looks repulsively dirty. It is a misfortune that the tree were ever brought into the country, for few people appear to know how to make a considerate use of it.

P. alba, var. **canescens** (Loudon, Encyc. 820). Fig. 16. Leaves broad or nearly circular in general outline, prominently notched but not lobed, the under surfaces and the young shoots

very white-woolly. This tree is met with occasionally. Its horticultural value is not greatly different from that of var. *nivea*.

P. alba, var. **Bolleana** (Lauche, Wochenschrift der Deutsche Garten, No. 32, Aug. 10, 1878. *P. Bolleana*, Lauche, l. c.). **BOLLES' POPLAR**. Fig. 17. A very tall and narrow-topped tree, with cottony leaves rather more deeply lobed than those of the var. *nivea*. The tree was introduced into Europe in 1875 from Turkestan, and it was named for Dr. C. Bolle, an arboriculturist. The tree bears about the same relation to *Populus alba* that the Lombardy poplar bears to *Populus nigra*. Its fastigiate habit combined with the white foliage and shoots, make it a most emphatic tree and there is great danger of planting it too freely.



17. *Populus alba* var. *Bolleana* ($\frac{2}{3}$ nat. size).

INDEX TO SYNONYMS.

- Populus angulata* = *P. monilifera*.
- Populus argentea* = *P. alba*, var. *nivea*.
- Populus Atheniensis* = *P. tremuloides*.
- Populus Bereolensis* = *P. laurifolia*.
- Populus betulifolia* = *P. nigra*.
- Populus Bolleana* = *P. alba*, var. *Bolleana*.
- Populus Canadensis* = *P. monilifera*.
- Populus canescens* of some = *P. alba*, var. *canescens*.
- Populus canescens* of some = *P. nigra*, var.
- Populus Carolina* = *P. monilifera*.
- Populus Carolinensis* = *P. monilifera*.
- Populus Certinensis* = *P. laurifolia*.
- Populus crispa* = *P. balsamifera*, var. *viminalis*.

- Populus dilatata* = *P. nigra*, var. *Italica*.
Populus Dudleyi = *P. balsamifera*, var. *viminialis*.
Populus elegans = *P. nigra*, var. *elegans*.
Populus Eugenie = *P. nigra*.
Populus fastigiata = *P. nigra*, var. *Italica*.
Populus glandulosa = *P. monilifera*.
Populus Græca = *P. tremuloides*.
Populus Græca pendula = *P. grandidentata*.
Populus Hudsonica = *P. nigra*.
Populus Italica = *P. nigra*, var. *Italica*.
Populus laurifolia of some = *P. balsamifera*, var. *intermedia*.
Populus laurifolia of some = *P. balsamifera*, var. *viminialis*.
Populus Lindleyana = *P. balsamifera*, var. *viminialis*.
Populus macrophylla = *P. candicans*.
Populus nigra pendula = *P. grandidentata*.
Populus nivea = *P. alba*, var. *nivea*.
Populus Nolestii = *P. balsamifera*, var. *latifolia*.
Populus Ontariensis = *P. candicans*.
Populus Pannonica = *P. nigra*, var. *Italica*.
Populus Petrovski = *P. laurifolia*.
Populus Polonica = *P. nigra*, var. *Italica*.
Populus pyramidalis = *P. nigra*, var. *Italica*.
Populus pyramidalis suaveolens = *P. balsamifera*, var. *viminialis*.
Populus pyramidata = *P. nigra*, var. *Italica*.
Populus rotundifolia = *P. Sieboldi*.
Populus salicifolia = *P. balsamifera*, var. *viminialis*.
Populus Sibirica pyramidalis = *P. balsamifera*, var. *intermedia*.
Populus trepida = *P. tremuloides*.
Populus Van Geertii = *P. monilifera*.
Populus viminialis = *P. balsamifera*, var. *viminialis*.
Populus Wobsky = *P. balsamifera*, var. *latifolia*.

COMPENDIUM.

Landscape gardening is the embellishment of grounds in such manner as to secure landscape or nature-like effects. The style of planting, therefore, should be free and easy, devoid of all formalisms and unusual or forced effects. There should be broad open spaces of greensward and heavy masses, or groups, of trees and bushes; and the heaviest plantings should be about the borders of the place. Scattered planting of individual trees and bushes is fatal to good effects. Trees which are simply odd or

curious introduce irrelevant and jarring effects, and they should never be made emphatic or prominent features of a place. Trees of very unusual or striking character, as the Lombardy and Bolle poplars, must, likewise, be used with the greatest caution, and, above all, their formality and strangeness should not be enforced by planting them in rows, in rural places.

The poplars are examples of trees which should be used only for secondary or incidental effects in landscape gardening, and never to construct the body or main features of the planting. Cheap trees produce cheap effects.

The Lombardy poplar may be used to advantage now and then in a group of trees to add spirit and vigor; but it should rarely be seen as an isolated specimen. The tree is used indiscriminately, because it grows rapidly in all situations and because its oddity pleases many people. It is so much abused that its legitimate value is obscured.

The varieties of the white poplar or abele are, in general, even less desirable than the Lombardy. As ordinarily planted, they are immodest and ugly trees, especially the whitest varieties, and their use in farm yards, country cemeteries and all small places should be discouraged.

Poplars which should be encouraged for ornamental planting are the common cottonwood, the common wild aspen, the normal or erect form of the large-toothed aspen, the *Certinensis* poplar, *Populus elegans* of the nurseries, and the European aspen.

Poplars of particular value for shelter belts and timber are the *Certinensis*, cottonwood, balm of gilead, and possibly *Populus Simonii*.

Species of rather heavy and dark foliage and strong growth, and which may be used for groups or masses, are the balm of gilead, *Nolestii*, and probably *Populus Sieboldi* and *P. Simonii*.

Among the species and varieties which are interesting because of natural peculiarities and which may be used for incidental effects or as single specimens, are *Populus angustifolia*, various forms of the balsam poplar (especially the variety *viminalis*), and forms of the European black poplar.

Weeping varieties are found in several species. The best is probably the drooping form of *Populus Tremula*, the European

aspen. There are good weeping forms of the large-toothed aspen (*Populus grandidentata*), but they are apt to be too stiff for the best effects in a drooping tree. There are yellow-leaved or variegated forms of some species, of which the best is the variety of the cottonwood known as Van Geert's golden poplar.

The best single species of poplar for general planting in New York, is probably the common cottonwood or Carolina poplar (*Populus monilifera*). The second choice is the new Russian species known as *Populus Certinensis* (properly *P. laurifolia*).

L. H. BAILEY.

1030.014

V7
C 826

7 OF 11.0.1
JUN 13 1903

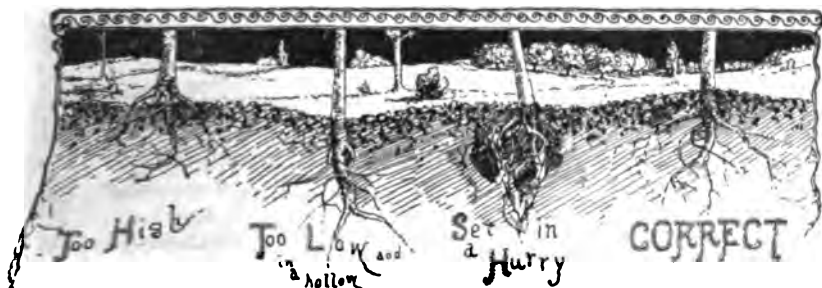
Bulletin 69.

August, 1894.

Cornell University Agricultural Experiment Station.

HORTICULTURAL DIVISION.

Hints on the Planting of Orchards.



By L. H. BAILEY.

PUBLISHED BY THE UNIVERSITY.

ITHACA, N. Y.

1894.

ORGANIZATION.

BOARD OF CONTROL: THE TRUSTEES OF THE UNIVERSITY.

STATION COUNCIL.

President, JACOB GOULD SCHURMAN.

Hon. A. D. WHITE,	-	-	-	-	Trustee of the University.
Hon. JOHN B. DUTCHER,	-	-	-	-	President State Agricultural Society.
Professor I. P. ROBERTS,	-	-	-	-	Agriculture.
Professor G. C. CALDWELL,	-	-	-	-	Chemistry.
Professor JAMES LAW,	-	-	-	-	Veterinary Science.
Professor A. N. PRENTISS,	-	-	-	-	Botany.
Professor J. H. COMSTOCK,	-	-	-	-	Entomology.
Professor L. H. BAILEY,	-	-	-	-	Horticulture.
Professor H. H. WING,	-	-	-	-	Dairy Husbandry.
Professor G. F. ATKINSON,	-	-	-	-	Cryptogamic Botany.

OFFICERS OF THE STATION.

I. P. ROBERTS,	-	-	-	-	Director.
E. L. WILLIAMS,	-	-	-	-	Treasurer.
H. W. SMITH,	-	-	-	-	Clerk.

ASSISTANTS

M. V. SLINGERLAND,	-	-	-	-	Entomology.
GEO. C. WATSON,	-	-	-	-	Agriculture.
G. W. CAVANAUGH,	-	-	-	-	Chemistry.
E. G. LODEMAN,	-	-	-	-	Horticulture.
MICHAEL BARKER,	-	-	-	-	Horticulture.

Office of the Director, 20 Morrill Hall.

Those desiring this Bulletin sent to friends will please send us the names of the parties.

BULLETINS OF 1894.

62. The Japanese Plums in North America.
63. Co-operative Test of Sugar Beets.
64. On Certain Grass-Eating Insects.
65. Tuberculosis in Relation to Animal Industry and Public Health.
66. Test of Cream Separators.
67. Some Recent Chinese Vegetables.
68. The Cultivated Poplars.
69. Hints on the Planting of Orchards.

CORNELL UNIVERSITY, ITHACA, N. Y. }
AUGUST 15, 1894. }

THE HONORABLE COMMISSIONER OF AGRICULTURE, ALBANY.

Sir: I submit the following suggestions on the planting of orchards for publication under Chapter 675, Section 87, of the laws of 1894. The information which is here presented is in almost constant demand by the farmers of the state.

L. H. BAILEY.

THE EXPERIMENT STATION EXTENSION, OR NIXON, BILL.

A law has been passed by the legislature and signed by the Governor, providing, amongst other things, an appropriation of \$8,000 to be expended by Cornell University for the benefit of horticulture in the Fifth Judicial Department of the State—an area comprising the counties of Cayuga, Seneca, Yates, Steuben, and counties to the westward. This fund is to be expended “in conducting investigations and experiments in horticulture; in discovering and remedying the diseases of plants, vines and fruit trees; in ascertaining the best means of fertilizing vineyard, fruit and garden plantations, and of making orchards, vineyards and gardens prolific; in disseminating horticultural knowledge by means of lectures or otherwise; and in preparing and printing, for free distribution, the results of such investigations and experiments, and such other information as may be deemed desirable and profitable in promoting the horticultural interests of the State.” This work is to be prosecuted by Cornell University “under the general supervision and direction of the Commissioner of Agriculture.”

Owing to the lateness of the passage of the bill, few definite lines of experiment could be undertaken the present season, but efforts are making in investigating the conditions and enemies of fruits and gardens, and especially in collecting and publishing the actual results of spraying orchards and vineyards. It is desired that any person or community which suffers an outbreak of any serious enemy shall communicate the fact to the undersigned, and, if possible, an expert will be sent to make an investigation. The causes of the failures of apple orchards is now the subject of a special investigation, and any person who has made experiments in spraying or fertilizing apple trees should advise us of the fact, in order that the results may be incorporated in the final report. Experiments are also in progress in various places in the fertilizing of orchard lands, and in other directions, the results of which will appear as they mature.

L. H. BAILEY, *Officer in Charge*,
ITHACA, N. Y.

HINTS ON THE PLANTING OF ORCHARDS.

It is presumed that the person who seeks the advice of this bulletin, has fully decided what kinds of fruits he desires to plant, and that he has satisfied himself that his markets, location and soil are adapted to them. He then enquires about the methods of preparing the land, the manner in which the trees should be set and trimmed, and the best place to purchase the stock. It is these questions which are continually recurring and concerning which this paper hopes to give some advice.

Preparation of land.—The soil in which orchards are set should always be in a thorough state of cultivation ; that is, whether in sod or in hoed crops, the land should be in good tilth or fine mechanical condition, fertile, and free from hard or “sour” places and pernicious weeds. There are exceptions to this rule in the case of certain rocky or steep lands upon which it is desired to set apples ; but for all orchards which are planted directly for commercial results, this advice has few, if any, exceptions. It is generally best to put the land into hoed crops the season before the trees are set, as potatoes or corn ; although sod land, if well fitted and naturally in good heart, often gives excellent results when turned over and set at once to orchards. But most soils need the previous cultivation to bring them into a mellow and uniform condition. Many of the “bad places” in orchards, where trees die out the first two or three years, could have been discovered and corrected if the land had been devoted to one or several hoed crops, for the owner would have observed that they were too wet or too lumpy or had other serious defects. Lands look more uniform when in sod than when cultivated, and the farmer may be led to overestimate their value for orchard purposes. It may also be said that the familiarity with a particular piece of land which comes of frequent cultivation, enables the careful grower to judge accurately of its adaptability to particular fruits or even to special varieties.

Lands which have hard and impervious subsoils should be plowed very deep before trees are put upon them ; and in some cases, as for dwarf pears, it may pay well to use the subsoil plow. Lands which hold surface water and which remain cold and "sour" long after rains, should always be thoroughly tile-drained before trees are set ; although it should be said that such lands are frequently unfit for orchards because of poor drainage of air as well as of water, and because the soil is likely to be hard and cloddy. It is undoubtedly true that tile-draining benefits all lands intended for orchards, but in the majority of cases, especially in rolling lands, it is a question if the labor and expense is worth the while. Yet many rolling lands require drainage because they have hard and tenacious subsoils which are near the surface. The clay lands upon which pears and plums thrive, give unusually good results if well underdrained.

When to plant.—There is much difference of opinion as to the relative merits of fall and spring planting. My own opinion is that fall planting is generally preferable to spring planting upon thoroughly drained soils, particularly for the hardy tree fruits, like apples, pears and plums ; and if the ground is in good condition and the stock well matured, peaches can sometimes be set in October with success. The advantages of fall planting are several. The trees become established during the open weather of fall and they usually make a start in spring before the ground is hard enough to allow of spring planting. This early start not only means a better growth the first season, but, what is more important, trees which get a very early hold upon the soil endure the drouths of midsummer much better than trees planted in spring. Planting is nearly always better done in the settled weather and workable soil of fall than in the capricious days and in the hurry of springtime ; and the orchardist is free to begin cultivation at a time when he would otherwise be planting his trees. Again, it is generally better to buy trees in the fall, when the stock of varieties is full and when the best trees are yet unsold : these trees must be kept until planting time, and it is about as cheap and fully as safe to plant them directly as to heel them in until spring.

In fall planting, however, it is important to insist that the trees shall be thoroughly well matured. In order to move stock

quickly, it is the practice of some nurserymen to "strip" the trees before the growth is completed; that is, the leaves are stripped off, the growth stopped, and the trees are put upon the market for September deliveries. This process weakens the trees, and I am satisfied that many failures which I have seen in young plantations in the State, are attributable to this cause. Such trees may die outright, especially if set in the fall and a hard winter follows; or they may live to make a dwindling growth for the first few years. Like early-weaned calves, they lack vitality and push. If I were setting an orchard in the fall, I should place my order for trees in August or September, if possible, with the express stipulation that the trees should stand in the nursery rows until the leaves begin to die and fall. In the meantime, I should endeavor to fit the land and dig the holes, so that when the trees arrive they can go directly into their places without delay or without the expense of heeling them in. Trees are mature enough to dig late in September or early in October in this State, depending upon the season, soil and variety. When the tree is fully mature, some of the leaves will still hold upon the vigorous shoots, and these are stripped off; but this stripping does no harm, for the young growth is then mature and it has a thick, strong, brown appearance which is quite different from the slender, soft and green branches of early-stripped trees.

It should be said that there seems to be a tendency amongst nurserymen to urge fall planting in order to push sales; and there are many good planters who consider fall planting hazardous. It is true that unless the conditions are right, spring planting is the safer course; and farmers who have many fall crops to harvest, will also find more time for tree setting in the spring.

Distance apart.—Trees are oftener set too close together than too far apart; in fact, the latter error scarcely exists. Trees are wide feeders; and the best results are obtained when each tree stands far enough from its neighbors to allow it to possess an individuality all its own. An additional reason for sparse planting has lately become important,—the necessity of spraying for insect and fungous pests; and for this reason, as well as to allow of better cultivation, the outside rows should not be set close to fences. The distance at which trees may be set, depends much upon the

system of pruning. If heading-in is followed vigorously and systematically, trees may be set a third nearer than if allowed to take their natural form. Heading-in should always be practiced with dwarf pears, and many of our best growers pursue it with peaches, plums and quinces. For myself, I have always advised thin planting as the safer rule for the majority of cases. The following table may be supposed to represent the outside average limit for the planting of orchards, when the trees are allowed to take their natural form :

Apples,	40 ft. each way.
Pears, standard,	20 to 25 ft.
Pears, dwarf,	12 ft. to 1 rod.
Quinces,	1 rod.
Peaches,	20 ft.
Plums,	20 ft.
Apricots,	20 ft.
Grapes,	6x8 to 8x10.
Currants,	4x6 to 6x8.
Blackberries,	4x7 to 6x9.
Raspberries,	3x6 to 5x8.

These are safe distances. In certain cases, however, where the soil is strong and the grower makes thorough work of cultivating, pruning and fertilizing, these distances can be reduced somewhat with profit, except in the case of apples. These remarks will also apply to the common question whether it is good policy to plant shorter-lived trees, as peaches, between apples and pears. It all depends upon the man. In general, I should discourage it; but if the orchardist gives the very best attention to fertilizing and cultivating, plantations can be mixed with good results.

How to plant the trees.—Plow the land and fit it well. As all orchards should be put into cultivated crops for the first two years, at least, it will generally be found advisable to plow the entire area before the orchard is set, rather than to plow strips where the trees are to go, for the land can then be shaped better with reference to surface drainage and general convenience. The trees should be set neither in dead-furrows nor on back-furrows. Level culture should generally be adopted from the start, unless it is necessary to displace surface water; and in that case it may be

PLATE I.



FIG. 1.—Sand cherry (*Prunus pumila*). Natural size.



FIG. 2.—Rocky Mountain Dwarf cherry (*Prunus Besseyi*). Natural size.

heavy snows. There are those who favor placing a forkful of manure in the bottom of the hole, but this is a practice of doubtful value; and, at all events, the manure should be well mixed with the soil to prevent drying out.

Making the rows straight.—It is difficult to make the rows straight in large areas, especially on rolling ground. I have had areas regularly surveyed with chain and compass and a stake set for every tree, but the orchards were as crooked as others set with much less care. The surveyor sets his stakes by sighting across the field from certain fixed points; but it is difficult for the planter, when the stake is removed and the hole dug, to stand the tree in the exact place of the stake. It is better to regard the trees as stakes and to set them by sighting. The area can be "run out" on two or three of the sides, a conspicuous stake being set at the location of each tree on these outside rows. If the field is large or rolling, it may be necessary to set one or two lines of stakes across the center of the field also. For areas of a few acres, I have found a garden-line stretched across the field to be a great help and to save much time. This line is moved at either end to the adjoining row, as soon as one row is set alongside it. I have sometimes tied conspicuous strings on the line at the given intervals between the trees, expecting to set a tree at every knot, but with the stretching of the line, and other sources of error, it is nearly impossible to get the trees straight in this manner, and the cross rows must be kept in line by sighting.

Mr. L. T. Yeomans, of Walworth, Wayne Co., one of the most successful fruit-growers in the State, gives me his method of marking out an orchard: "The plan which we have always used is simple and very effective. I have seen rows of apples 30 rods in length so straight that one could not see a pitchfork handle held upright in the row, and which rowed as straight diagonally as in the square. To plant an orchard of considerable size, provide straight sticks about four feet long (common lath are very suitable); whitewash about one-half of their length on both sides. Measure the distance on the outside of the boundary rows around the field, setting a perpendicular stake at the distances you desire the rows apart; then set an intermediate row of stakes across the

middle of the field each way by having one person set the stake while another person sights him from a stake at the side of the field to the corresponding stake at the opposite side. No stake or row of stakes should be set where a tree or row of trees will come. Thus the entire orchard may be planted without removing a stake and the rows must be straight if the man who plants the trees has a 'good eye.' Any man after a little showing, can dig holes in the proper places by sighting in two lines at right angles from himself in the direction in which there are two stakes in line, as will always be the case wherever he may be in the field. If the ground is very uneven, or the field very large, more than one intermediate row of stakes will be useful."

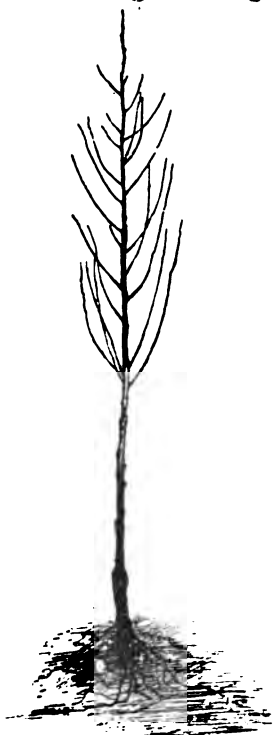
Trimming the trees.—There is much difference of opinion as to the best method of trimming trees when they are set. So far as the root is concerned, it is advisable, in the North, to cut away only those roots which are broken or badly torn. These should be cut off just back of the injury. It is the custom to cut off the ends of all roots of the size of a lead pencil or larger, for a clean smooth wound is supposed to heal quicker than a ragged one. These cuts are made from within outwards, so that the wound is more or less slanting across the roots and so that it rests firmly upon the ground when the tree is set. When the tree is planted, all the roots should be straightened out to nearly or quite their normal position. If it is found that one or two roots run off to an inordinate length, they may be cut back to correspond somewhat with the main root system.

Perhaps half the entire root system of the young tree is left in the ground when it is dug. It is therefore evident that the top should be cut back to a corresponding amount. In fact, the top should be more severely shortened in than the root, because the root, in addition to being reduced, is also dislodged from the soil, with which it must establish a new union before it can resume the vital activities. Trees which are allowed to carry too much top when planted, may fail to grow outright; or if they start, they are very likely to be overtaken by the drouths of summer. Even if they live, the growth is generally small and uncertain, and the tree may fall a prey to borers or a victim to high winds. On the other hand, I am convinced that trees are sometimes trimmed too

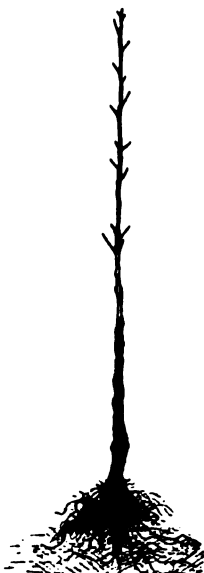
severely when set. Except possibly in the case of peaches, I think it generally unwise to trim the trees to a mere pole; and with peaches, I think it better to leave spurs with at least one bud than to trim to a whip. There should be a number of strong bright buds left upon the top, for these are the points where early and active growth begins. These buds are upon strong branches.

If they are removed, the weaker or half dormant buds upon the main trunk or low down in the crotches, must take up the work, and these start slowly and often feebly.

There are two general methods of trimming the tops of young trees at planting time. One method cuts back all the branches to spurs of from one to three buds; or sometimes, particularly with dwarf pears set when two years old, the side branches may be cut entirely away, leaving only the buds on the main stem or trunk. The tree therefore "feathers out" the first season; that is, it



1. Yearling Peach Tree.



2. Peach tree, pruned.

shoots along the main trunk. The following fall or spring, the top is started at the desired height. Fig. 1 shows a peach tree as received from the nursery, and Fig. 2 the same tree, trimmed in this manner, ready for planting. This method is the one generally best adapted to the peach, which is always set when a year old; but for other fruits, unless the trees are slender and without good branchy tops, it is doubtful if it is the best practice. If the bodies are thought not to be stiff enough, this manner of

trimming may be used to good advantage. The main shoot should usually be headed back in this as in all styles of trimming, in order to make the trunk stocky.

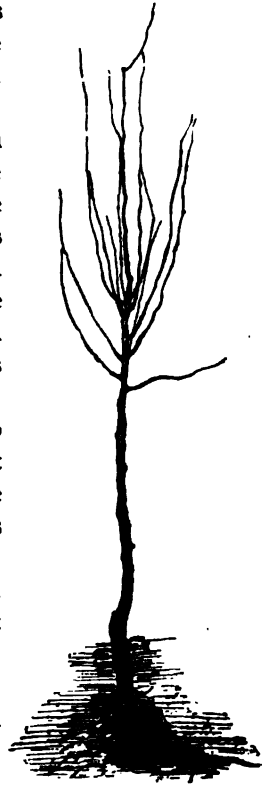
The second method aims to start the top at the required height when the tree is planted. It is adapted only to strong and well grown stocks which have a more or less branching and forking top. From three to five of the best branches are left, and these are headed back to a few buds each. Fig. 3 shows a pear tree, trimmed in Fig. 4, and the illustration may be considered to represent a good example of its class. Many of our best planters

prefer the spur system for all trees, and there are some who would trim all newly set trees to a straight whip; but there is much to be said for this last method, and I have used it many years with uniform success.

It may be said in general, then, that peach trees and small or slender trees should be well headed back and spurred (Figs. 1, 2); but that strong, well branched trees may have the head



4. Pear tree pruned.



3. Three year old Pear tree.

started at the desired height at the time of setting, all the branches being well headed back (Fig. 3 and 4).

The trees may be trimmed before they are planted, although I prefer to do it just after they are set, especially if the tree is trimmed after the method of Fig. 4, for one can then better estimate the proper height, the operation is easier done, and there is

no further danger of breaking off the limbs by the handling of the tree. One foot is planted firmly at the base of the tree, and then with one hand the branch to be removed is bent upwards and with the other the knife is applied to the under side and the cut is made neatly and easily (Fig. 5). Never cut downwards on a limb, for a ragged wound nearly always follows.

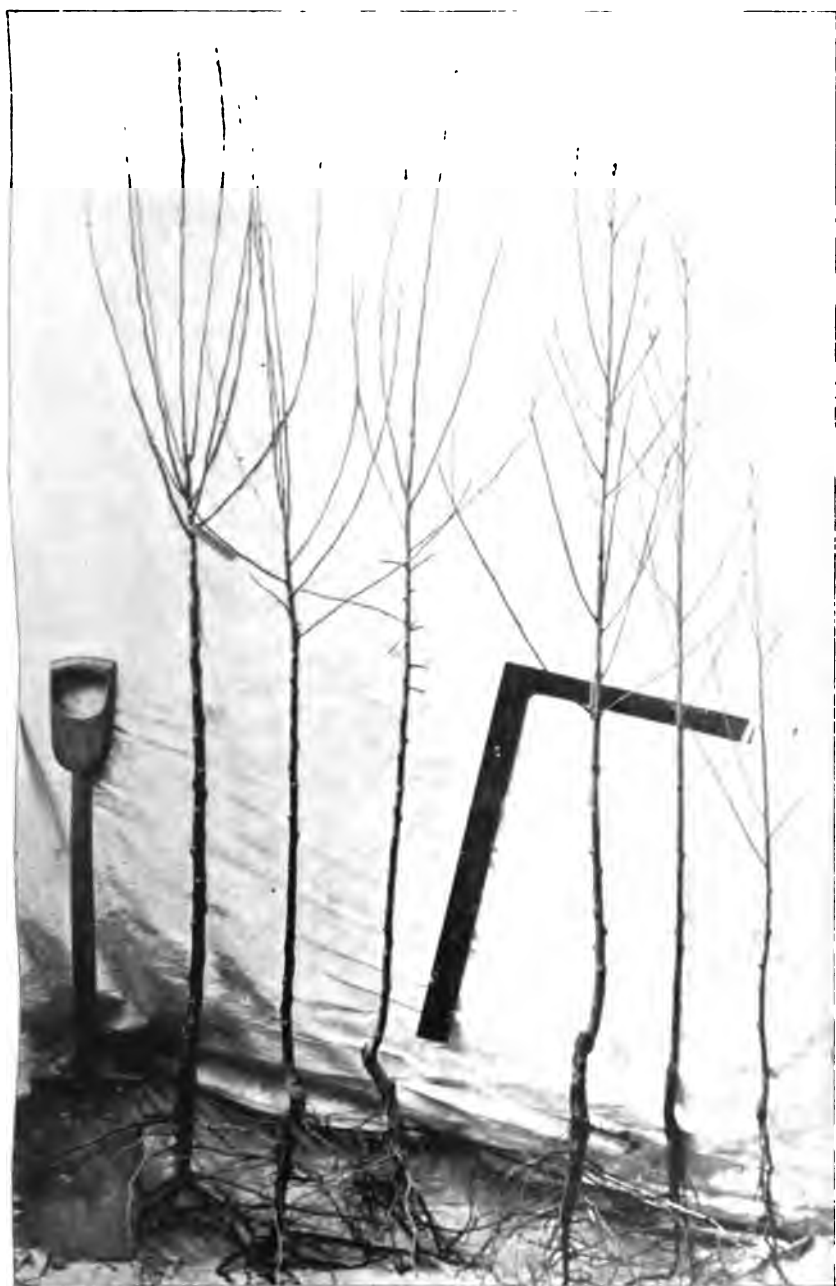
Buying the trees.—I have already said that it is best, when it can be done, to order trees late in summer or early in the fall, if



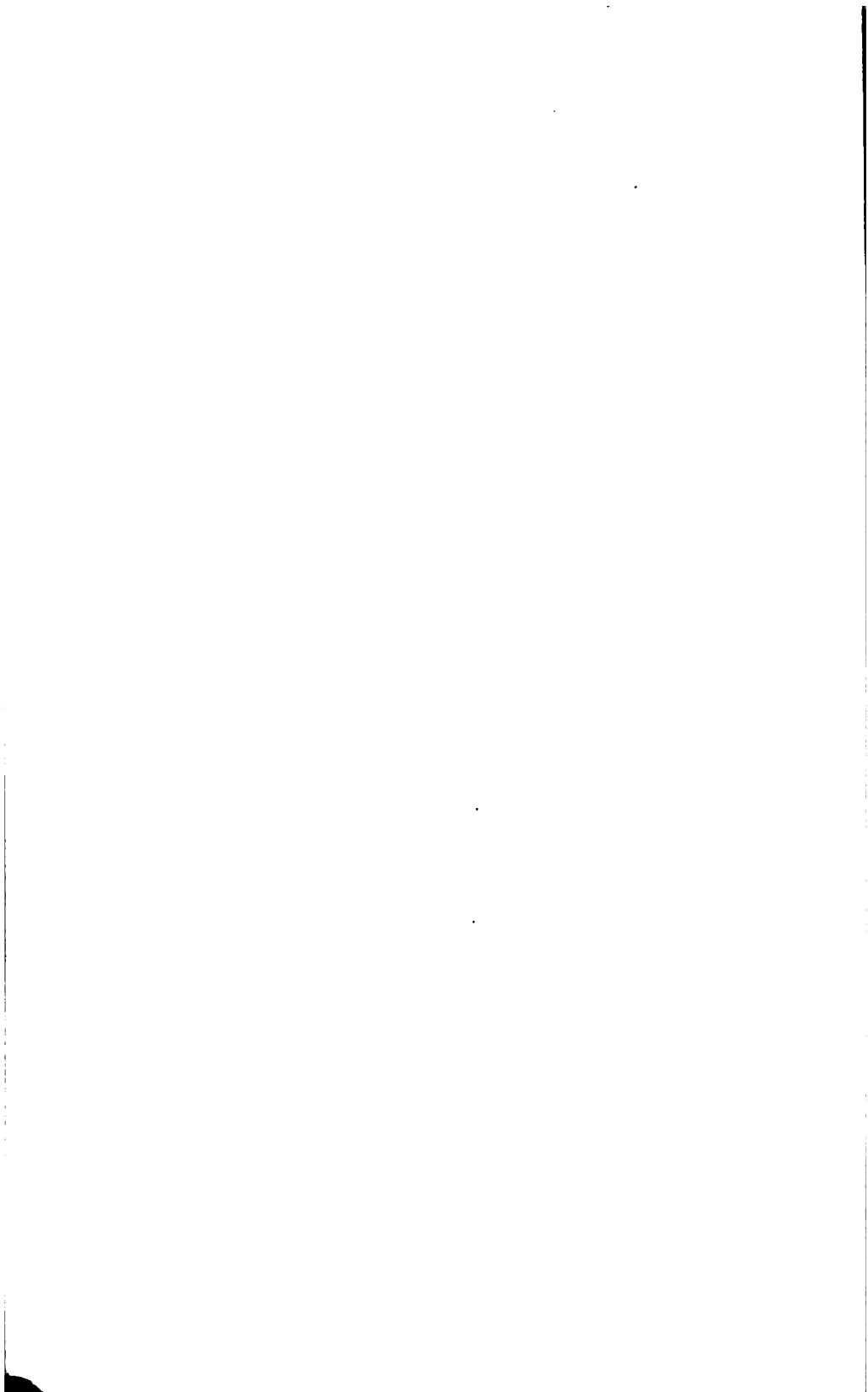
5. *Pruning a young tree.*

one expects to plant an orchard. Buy where the best trees can be obtained, and where there is good reason to expect reliable stock and honest dealing. While one should endeavor to secure low prices, it should be remembered that nursery stock should never be purchased simply because it is cheap. Poor stock is dear as a gift. Yet farmers who annually plant a few trees and who buy of agents, often pay exorbitant prices. In a certain town last spring, farmers were paying 28 cents apiece for peach trees in lots of a dozen, while any reliable nursery would have been glad to have supplied the same varieties at \$8.00 per hundred, at the nursery.

Plums which should have sold for 15 cents to 20 cents apiece were selling to farmers for 50 and 60 cents apiece. The man who seriously expects to plant an orchard for profit, will not be led into any wild scheme or new varieties by agents. He will generally buy directly of the nearest nurseryman who can supply the desired stock and varieties at the prices which suit him. Some nurserymen employ regular and reliable agents, and such agents carry a certificate from the firm they represent. But while these salesmen may be perfectly straightforward and may be the best channels through whom small orders can be secured by those who are uninformed in



6. *Apple (Hubbardston) and Peach (Elberta) trees of first, second and third class respectively. Apples (at the left) two years old ; peaches, one year old.*



pomological matters, I should advise all persons who expect to go into fruit growing seriously to buy directly of the nurseries. But it must always be remembered that the tree agent has been the means of clothing the country with fruit trees, and of thereby adding much to the contentment of farm life.

The buyer should make up his mind just what varieties he wants and then find the nursery which has them, and order early enough to get them. There is then no occasion to consider the vexed question of substitution of varieties. If the varieties are not in market, buy stocks of some strong growing staple variety, and after these are established—usually the same summer or the following spring—bud or graft over the tops to the desired varieties.

It is generally best to buy first-class trees,—those which are of medium size for their age, shapely, stocky, with straight clean trunks, which are not stunted and are free of borers and other injuries, and, in the case of budded trees, those in which the union is very near the ground. In dwarf pears, especially, it is important that the stock, to be first-class, shall be budded very low. The accompanying sketch (Fig. 6) shows trees of apple and peach of first, second and third class. These are New York grown trees, the apples two years old from buds. It is often thought that large size is of itself a great merit in a nursery tree, but this is an error. Vigor, straightness, stockiness, firm hard growth, are much more important than bigness. The toughest and best trees are usually those of medium size.

The age at which trees should be bought must be governed by circumstances and by variety. There is a general tendency to buy trees too old rather than too young. When varieties are new and scarce, it may be economy to buy young stock. This will, no doubt, be true of Japanese plums the present year, and good yearling trees will give excellent results. Less vigorous kinds of plums would not be so satisfactory at this age. Some of the freer growing apples and pears are large enough when two years old, if grown from buds; but these fruits are usually set at three years from the bud or graft. Dwarf pears may be set at two or three years, preferably, I think, the former age. Quinces are set at two and three years. Peaches are always set at one year from the bud.

After care.—Always cultivate the orchard thoroughly and fre-

quently for at least the first two years after planting. Sowed crops should always be avoided in young orchards. Oats is the worst crop which can be used, for it stands on the ground longer than wheat and pumps out the moisture at a time when it cannot be spared ; and in all sowed crops there is no conservation of moisture by cultivation. It should also be said that trees in wheat, oats or barley are not seen so frequently as those in cultivated crops, and borers, tent-caterpillars, accidents by winds, and other injuries, are not so soon detected. The man who hopes to raise an orchard and grain on the same ground, had better leave the orchard unplanted.

With tender trees, like the peach, and particularly on moist lands, cultivation should generally stop a month before heavy frost is expected, in order to allow the wood to mature. A good crop for such cases is early potatoes. Corn or any vegetable crop is also suited to a young orchard.

Watch the trees carefully for borers. The most serious borer in newly set trees is often the flat-headed species which works under the bark, especially where it is exposed to the sun, as upon any crook or elbow of the tree which may, unfortunately, have been turned to the south in setting the tree. Tent-caterpillars may be expected in June and fall web-worms late in the season. In the fall, see that no litter in which mice can nest, is allowed to lie about the trees. It will not be necessary to hill up the trees for winter protection in land which does not heave, although it is well to have the ground slope gradually away from them in order to carry off surface water ; and if there is any danger of mice, because of refuse grass or litter about the trees, hilling of the trees will generally prevent injury. Mice are effectually repelled by a strip of tarred paper rolled lightly about the base of the tree.

The subsequent care of the orchard is a matter which must be determined for each individual case, and it is not the province of this essay to deal with it. A later bulletin (No. 72) will be devoted to that subject.

L. H. BAILEY.

30,679
N7
C89b

A. L. Quarantine

Bulletin 70.

August, 1894.

Cornell University Agricultural Experiment Station.

HORTICULTURAL DIVISION.

THE NATIVE DWARF CHERRIES.



By L. H. BAILEY.

PUBLISHED BY THE UNIVERSITY.

ITHACA, N. Y.

1894.

ORGANIZATION.

BOARD OF CONTROL:

THE TRUSTEES OF THE UNIVERSITY.

STATION COUNCIL.

President, JACOB GOULD SCHURMAN.

Hon. A. D. WHITE,	-	-	-	-	Trustee of the University.
Hon. JOHN B. DUTCHER,	-	-	-	-	President State Agricultural Society.
Professor I. P. ROBERTS,	-	-	-	-	Agriculture.
Professor G. C. CALDWELL,	-	-	-	-	Chemistry.
Professor JAMES LAW,	-	-	-	-	Veterinary Science.
Professor A. N. PRENTISS,	-	-	-	-	Botany.
Professor J. H. COMSTOCK,	-	-	-	-	Entomology.
Professor L. H. BAILEY,	-	-	-	-	Horticulture.
Professor H. H. WING,	-	-	-	-	Dairy Husbandry.
Professor G. F. ATKINSON,	-	-	-	-	Cryptogamic Botany.

OFFICERS OF THE STATION.

I. P. ROBERTS,	-	-	-	-	Director.
E. L. WILLIAMS,	-	-	-	-	Treasurer.
H. W. SMITH,	-	-	-	-	Clerk.

ASSISTANTS.

M. V. SLINGERLAND,	-	-	-	-	Entomology.
GEO. C. WATSON,	-	-	-	-	Agriculture.
G. W. CAVANAUGH,	-	-	-	-	Chemistry.
E. G. LODEMAN,	-	-	-	-	Horticulture.
MICHAEL BARKER,	-	-	-	-	Horticulture.

Office of the Director, 20 Morrill Hall.

Those desiring this Bulletin sent to friends will please send us the names of the parties.

BULLETINS OF 1894.

62. The Japanese Plums in North America.
63. Co-operative Test of Sugar Beets.
64. On Certain Grass-Eating Insects.
65. Tuberculosis in Relation to Animal Industry and Public Health.
66. Test of Cream Separators.
67. Some Recent Chinese Vegetables.
68. The Cultivated Poplars.
69. Hints on the Planting of Orchards.
70. The Native Dwarf Cherries.

CORNELL UNIVERSITY, ITHACA, N. Y. }
August 20, 1894. }

THE HONORABLE COMMISSIONER OF AGRICULTURE, ALBANY,

Sir: I herewith submit to you, for publication under Chapter 675, Section 87, of the laws of 1894, a sketch of the Native Dwarf Cherries, a type of fruits which it is proposed to employ in the utilization of certain waste lands in Western New York.

L. H. BAILEY.

much larger and looser pit, and have a drier flesh. Probably Alexander is mixed with this in our orchard.

Alexander.—About a week or ten days later than Catherine and Budd. Fruit small, oblong, and flattened, orange-yellow, with a faint blush cheek, the flesh firm and rather coarse. Pit larger and loose. This and the late form of Nicholas, mentioned above, seem to be the same thing. About the season of the Breda, with us.

Gibb.—Three or four days later than Catherine and Budd, and somewhat larger, oblong and flattened. Color a light lemon or white-yellow, with only a trace of color in the cheek. Flesh juicy and tender, but lacking in flavor, and somewhat acid. Pit rather large and loose.

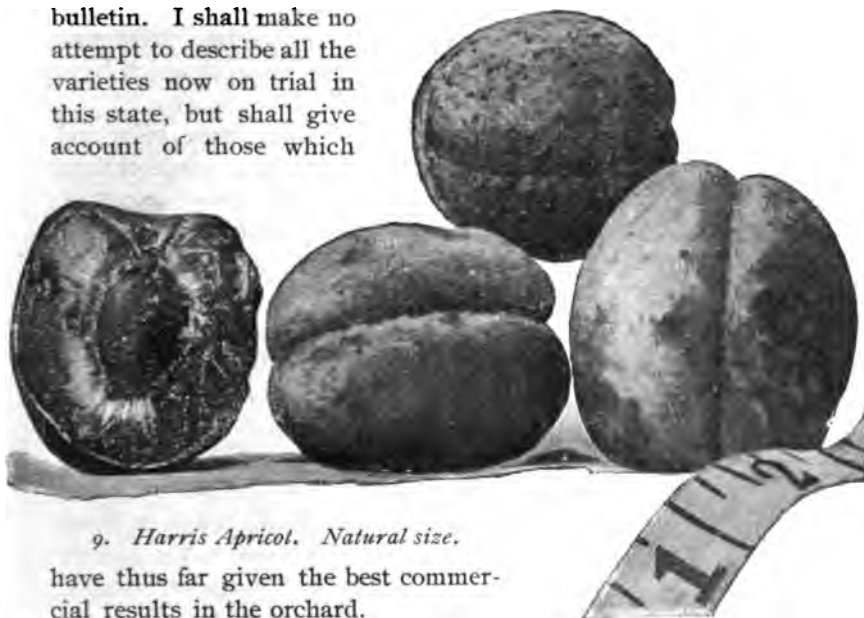
These five are the only Russian varieties which we have fruited. None of them are as good either in quality or size, as Royal, Breda, Early Golden, and other varieties.

Some four years ago I made an inquiry into the history and merits of the Russian apricots, and the conclusions of that investigation* are still correct, so far as I know.

1. The Russian apricot is somewhat hardier than the peach, and may be expected to endure the climate a degree or two north of the peach belt.
2. It blooms early (like the common apricot) and is liable to injury from late spring frosts.
3. Seedlings vary widely, and many of them are worthless.
4. The fruit, even of the best sorts, is much inferior to that of the older and better known varieties of apricots.
5. There is promise of considerable improvement in the varieties under proper care and selection.
6. The fruit is particularly liable, in common with other apricots, to the attacks of the curculio, and in the West to the attacks of the plum gouger.
7. In general, it appears that on the northern limits of peach culture, the best varieties of Russian apricot are worth cultivation on a limited scale, but they cannot compete with other apricots in places where the latter can be grown.

* American Garden, xi. 645.

The best apricots.—It is impossible, at the present time, to state with much confidence what apricots are best adapted to Western New York and its markets. Many varieties have been tried by various growers, particularly by E. Smith & Sons, Geneva, the most extensive apricot growers in the state, and to whom I am greatly indebted for much of the information contained in this bulletin. I shall make no attempt to describe all the varieties now on trial in this state, but shall give account of those which



9. *Harris Apricot. Natural size.*

have thus far given the best commercial results in the orchard.

Early varieties.

Smith's Early.—A flattish apricot of medium size, or even large for an early variety, ripening from the 1st to the 10th of July. It is ordinarily very productive, and the quality is good. The origin of this variety is unknown. The original tree was growing in a yard in Geneva when the place passed into the hands of William Smith. The variety began to be propagated about ten years ago.

Harris (Fig. 9).—I am entirely unable to determine if the Harris and Smith's Early are distinct. Last year I thought them the same, but this year I thought that I saw some fairly constant differences in the fruit; but if not perfectly identical, they are so

much alike that they cannot be distinguished by printed descriptions. The Harris is also the product of a single tree found in a Geneva yard, the property of Edwin Harris. The variety was first propagated about the same time, or perhaps somewhat earlier, than the Smith's Early. It is probable that both varieties are some English sort of which the name has been lost. The Harris is a poor grower in the nursery, and it is not yet sufficiently tested to enable me to recommend it. But these two varieties constitute the best type of very early apricots which have yet been grown in Western New York.

Early Moorpark.—A rather small apricot, in shape, color and quality resembling the Moorpark, but about three weeks earlier. It is productive, and of better quality than the above varieties, but its small size is against it for a general market fruit.

St. Ambroise.—A well known large early apricot, of flattish shape, and deep yellow color, reddish in the sun, of excellent quality. It is a favorite variety in England, and is said by Hogg* to be "the most prolific variety in cultivation."



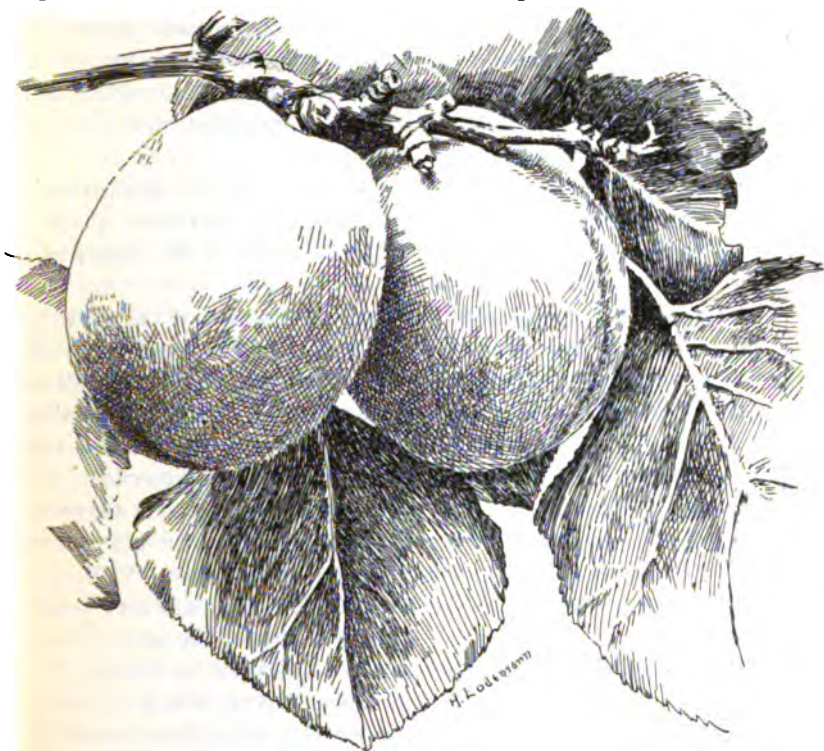
10. *Turkish of Western New York.*
Natural size.

Mid-season and late varieties.

—**Turkey or Turkish (Roman?)**—One of the very best of the apricots grown in Western New York is the variety known as Turkey or Turkish, and shown natural size in the engraving (Fig. 10). It is a very large, flattish and elongated fruit, with a rich orange ground shaded with red, and a firm, good flesh. The tree is a very strong grower, the foliage dense and dark, and it is very productive. This variety is very like the Montgamet, except that it is a week or two earlier.

* Fruit Manual, 5th ed. 272.

It is probable that this apricot is improperly named, for the Turkey of the fruit manuals is said to be very late, ripening even after Moorpark, whilst this variety is probably two weeks earlier than Moorpark. Both Downing and Hogg describe the Turkey apricot as medium size, round, not compressed, and Downing



11. *Roman Apricot. Natural size.*

says that it "is a fine old variety which is seldom seen in our gardens, the sort generally sold under this name being the Roman." Wickson* says that the Turkey is "commended by Southern California Nurserymen's Association as good for home use, but too juicy for canning or market"—a description which will not fit our variety.

The Roman is also grown in Western New York, and it seems

*California Fruits, 260.

to be the same as the above. Fig. 11 shows specimens of average size grown under this name. I have not seen an apricot in this region which seems to answer to the characters of the Turkey.

Montgamet (*Alberge de Montgamet*).—An old variety, and apparently one of the most productive and best market apricots yet tested in the State. The variety grown here under this name is much like the Turkish described above, but somewhat later. Smith's Triumph, originated with W. W. Smith, Vacaville, California, is very much like the New York Montgamet, and possibly indistinguishable from it.

Royal.—A French variety of large size, slightly compressed, with a dull yellow skin and a red cheek, of excellent quality. One of the best, ripening about a week ahead of the Moorpark. Likely to overbear.

Moorpark.—This is probably the best known of the apricots grown in the North, in this country. It is the latest one yet proved in Western New York, ripening from the 10th to the middle of August. The fruit is large to very large, with a light orange skin and deep orange or orange-red blush in the sun, compressed, one side usually larger than the other. The quality is superior. Altogether, it is one of the very best of all apricots, and it seems to be a heavy bearer in Western New York, although Downing says that "it is only a moderate bearer here [Hudson River Valley]."

Amongst the varieties less known, the following are very promising for Western New York: Luizet, a French variety; Jackson, originated on the farm of Andrew Jackson, in Fresno Co., California; Allison, a seedling of White Royal, raised by Josiah Allison, near Vacaville, California; Eureka, a seedling grown by I. H. Thomas, Tulare Co., California.

REVIEW.

1. The apricot is adapted to cultivation in Western New York, and it is already grown to a commercial extent.

2. The chief general difficulties in the way of its cultivation, aside from ignorance concerning the fruit, are the habit of early blooming and consequent liability to injury by late spring frosts, and the ravages of the curculio.

3. Injury from frost is to be avoided by choosing frostless locations, as those adjoining bodies of water, and by avoiding too "early" lands.

4. The curculios can be kept in check when they are caught and killed; and this is best done by jarring them onto sheets, in the same manner long followed in plum and peach orchards.

5. It is not yet certain what are the best stocks for apricots in Western New York. It is probable that no one stock is best under all circumstances. The apricot root itself seems to be impatient of our cold and wet soils, which are drenched by the drainage of winter. It needs a very deep and rich soil, but it is doubtful if it is safe for this state. The common plum (not myrobalan) is an excellent stock for plum soils, and the apricot does well either nursery-budded or top-worked upon it. Peach is probably the commonest stock, and for peach soils it is probably the best that can be used. If the apricot thrives upon various stocks, it is thereby adapted to many soils.

6. The cultivation, pruning and care of the apricot are not unlike the attention given to the peach; and it may be expected to be about as productive as the peach.

7. There are three species of apricots in cultivation in Western New York,—the Black or Purple, the Japanese or Chinese, and the common types.

8. The Black or Purple apricot (*Prunus dasycarpa*), of unknown nativity, is a fruit of comparatively small merit. The fruits are round and plum-like, stalked, fuzzy, very dark red in skin and flesh, the latter soft and subacid and clinging tightly to the pit. It is not grown for market.

9. The Japanese or Chinese apricot (*Prunus Mume*), native to Japan, is represented in this state chiefly by the Bungo or Bun-

goume. It differs from the common apricot in peculiarities of foliage, fragrant flowers which are double in many ornamental varieties, and small, hard clingstone fruits which are of little value.

10. The common apricot type (*Prunus Armeniaca*), originally from Northern China, comprises two groups,—the Russian and the common sorts.

11. The Russian apricots appear to be somewhat hardier than the ordinary type, but beyond this fact they appear to have no merit for Western New York; and the common apricots are sufficiently hardy here. The fruit is small and mostly poor, as compared with our standard sorts.

12. The varieties of apricot most prized for commercial planting in Western New York appear to be Smith's Early, Harris, Early Moorpark, St. Ambroise, Turkish (probably Roman), Montgamet, Royal, and Moorpark. Varieties less known but very promising, are Luizet, Jackson, Allison and Eureka.

L. H. BAILEY.

630.619

N7
C82b

Bulletin 72.

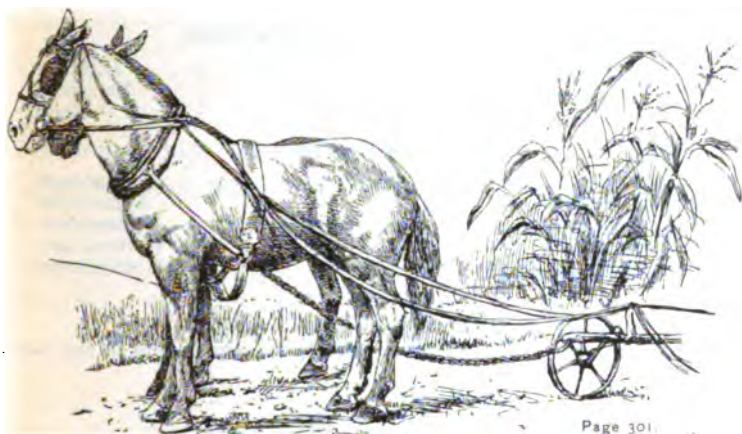
September, 1894.

UNIV. OF MICH.

Cornell University Agricultural Experiment Station

HORTICULTURAL DIVISION.

THE Cultivation of Orchards.



By L. H. BAILEY.

PUBLISHED BY THE UNIVERSITY.

ITHACA, N. Y.

1894.

ORGANIZATION.

BOARD OF CONTROL:

THE TRUSTEES OF THE UNIVERSITY.

STATION COUNCIL.

President, JACOB GOULD SCHURMAN.

Hon. A. D. WHITE,	-	-	-	-	Trustee of the University.
Hon. JOHN B. DUTCHER,	-	-	-	-	President State Agricultural Society.
Professor I. P. ROBERTS,	-	-	-	-	Agriculture.
Professor G. C. CALDWELL,	-	-	-	-	Chemistry.
Professor JAMES LAW,	-	-	-	-	Veterinary Science.
Professor A. N. PRENTISS,	-	-	-	-	Botany.
Professor J. H. COMSTOCK,	-	-	-	-	Entomology.
Professor L. H. BAILLY,	-	-	-	-	Horticulture.
Professor H. H. WING,	-	-	-	-	Dairy Husbandry.
Professor G. F. ATKINSON,	-	-	-	-	Cryptogamic Botany.

OFFICERS OF THE STATION.

I. P. ROBERTS,	-	-	-	-	-	Director.
E. L. WILLIAMS,	-	-	-	-	-	Treasurer.
H. W. SMITH,	-	-	-	-	-	Clerk.

ASSISTANTS.

M. V. SLINGERLAND,	-	-	-	-	-	Entomology.
GEO. C. WATSON,	-	-	-	-	-	Agriculture.
G. W. CAVANAUGH,	-	-	-	-	-	Chemistry.
E. G. LODEMAN,	-	-	-	-	-	Horticulture.
MICHAEL BARKER,	-	-	-	-	-	Horticulture.

Office of the Director, 20 Morrill Hall.

Those desiring this Bulletin sent to friends will please send us the names of the parties.

BULLETINS OF 1894.

62. The Japanese Plums in North America.
63. Co-operative Test of Sugar Beets.
64. On Certain Grass-Eating Insects.
65. Tuberculosis in Relation to Animal Industry and Public Health.
66. Test of Cream Separators.
67. Some Recent Chinese Vegetables.
68. The Cultivated Poplars.
69. Hints on the Planting of Orchards.
70. The Native Dwarf Cherries.
71. Apricot Growing in Western New York.
72. The Cultivation of Orchards.

CORNELL UNIVERSITY, ITHACA, N. Y., }
Sept. 1, 1894. }

THE HONORABLE COMMISSIONER OF AGRICULTURE, ALBANY.

Sir: The following sketch of the philosophy of the cultivation of orchards, a sequel to Bulletin 69, is submitted for publication and distribution under Chapter 675, Section 87, of the Laws of 1894.

L. H. BAILEY.



Ideal cultivation of peach orchards. The upper cut illustrates what I believe to be, in general, the best method of pruning peach trees.

THE CULTIVATION OF ORCHARDS.

There is probably no subject upon which pomologists differ so widely as the methods of cultivating orchards. These differences arise very largely from the different soils and circumstances of the various orchards, and it is useless to attempt to reduce them to one system of practice. Yet, whilst all advice touching the cultivation and management of fruit plantations must be subject to many exceptions and modifications, there are certain underlying principles which every fruit-grower must consider and which must form the basis of all operations.

The object of all cultivation is to furnish the plant with the best materials and conditions of growth. Plant food must be supplied and moisture must be conserved. It should always be remembered that the soil itself is the greatest storehouse of plant food and that the first consideration of the farmer should be the attempt to utilize it. The application of plant food in the form of farm manures or other fertilizers must always be a secondary consideration. It should also be known that the very treatment which best utilizes the natural food resources of the soil, is also the best conservator of moisture. This treatment is tillage.

Preliminary considerations.—All subsequent treatment will fail of best results if the original preparation or selection of soils is imperfect or hasty. In the first place, the fruit grower must be sure that his soil and location are adapted to the particular fruit he desires to plant. In the second place, the soil itself should be in good condition before the trees are set. Soils which enjoy perfect natural drainage are particularly desirable for orchards, because they are not only warm and give up their fertility easily, but because they also allow of very early cultivation, which is an important requisite in the management of orchards. If this perfect natural drainage does not exist, tile-drainage should be employed, until the soil is brought into the best possible condition. It should be said that many hard and wet soils make excellent pear and plum lands when thoroughly tile-drained. It is a com-

mon opinion that only flat lands need draining, but one often finds rolling lands in which the subsoil is high and hard and holds the water like a wet blanket. Judicious draining not only carries off the superfluous water, but it also loosens the subsoil and allows it to retain its moisture better in times of drouth. An attempt should be made to bring the land in the various parts of the orchard into conditions as uniform as possible, so that the same tillage and treatment may be applied to the entire area. All hard and "sour" spots should receive particular care in draining and subjugation, or they should be left outside the plantation. The present season has enforced the importance of good drainage in the orchards of New York to an extent which I have not known before. The spring was very wet and the summer has been very dry. In most orchards cultivation began so late that the most assiduous attention during the later months has not been able to correct the delay, and the effects of the drouth have thereby been intensified.

Theory of tillage of orchards.—The first object of tillage is to furnish plants with food. A fine mechanical condition of the soil allows the plant to reach every portion of it, and aids greatly in unlocking and utilizing materials which are more or less unavailable.

But the advantage of tillage which I wish now to impress upon the reader, is its conservation of moisture. The first plowing or cultivation in the spring should be rather deep, in order to send the roots deep into the soil; and this result will be more easily accomplished if the land is either naturally or artificially well drained. Subsequent cultivation should be shallow and very frequent, in order to make a mulch of the surface soil. The best mulch—that is, the best conservator of moisture—is a frequently stirred, soft and fine surface soil. And all the grateful effects of this surface mulch are ordinarily most marked when the soil contains considerable vegetable fibre or humus, which, of itself, is a conservator of moisture.

But if orchards should be plowed early in spring, it does not follow that they should be plowed in the fall. In fact, fall plowing is commonly to be discouraged, for it leaves the soil in an open and loose condition which may be injurious to the roots, and

it often starts the trees too early in the spring. I know persons who plow vineyards late in the fall for the express purpose of starting an early growth and of securing an early crop; but this is safe only in those favored localities where late spring frosts are practically unknown. Fall plowing may be advisable as a preparation for many farm crops, but it is not generally best for orchards. Cultivation should also generally stop late in summer or early in fall, as explained further on (page 305).

If the above propositions are true, it follows that the best results are obtained only when this treatment is applied from the start. It is in the first two or three years of the life of the orchard that the roots are strongly deflected downwards under the influence of cultivation. Orchards should never be put into sowed crops or into grass for the first five years of their life, and grain crops should always be withheld. Everywhere one may see young orchards in wheat-fields or oat-fields, and the short growth, knotty bodies and yellow leaves tell the story of shallow roots, dry soil, borers, and all the ills which every farmer who follows such methods deserves to have fastened to his trees. A useful lesson upon the value of cultivation in conserving moisture is given upon a following page (306), under the discussion of green manures. I am convinced that many of the apple orchards of New York state were ruined in their youth by just such methods, and that no amount of subsequent cultivation can send the roots down where they belong. The best treatment for many orchards in the state is extermination. If there is any profit in them, it is for fire-wood.

Cultivate the orchard from the first and begin the cultivation early. "But I don't have time; there is too much farm work to be done," I hear everywhere. Then do not plant the orchard! It is strange that farmers feel that if anything is to be neglected it must be the orchard. Perhaps it would be well to put the most attention upon the most profitable part of the farm, and as likely as not this part will turn out to be the orchard. This dialogue occurred in Niagara county this year:

"You should cultivate your peach orchard better and get into it earlier."

"Yes, I know; but farm work was too pressing, and I couldn't," replied the owner.

"What part of your farm brings you the most money?" asked the visitor.

"Well," said the other, reflectively, "I guess it is the peach orchard."

"Then I should attend to the peach orchard first, and let the farm work go."

"Say, that's so! I hadn't thought of it in that way before," and the owner has turned down a new leaf.

Methods of cultivating.—The best tillage is that which begins early in the season, and which keeps the surface stirred until late summer or early fall, and the best implements are those which secure this result with the least amount of time and labor. For the first few years, it is generally advisable to turn the land rather deeply with a plow at the first spring cultivation. There are many styles of clod crushers, spring-tooth harrows, cut-aways, and smoothing harrows which will adapt themselves readily to the cultivation of the particular soil in question. In all friable or loose soils, shallow cultivation is always preferable, and in these some form of cut-away or smoothing harrow will be found to be efficient. When the land is once in good condition, but little effort and time are required to run through the orchard. Crust should never be allowed to form upon the surface, and weeds should be killed before they become firmly established. The entire surface of the orchard should be stirred as often as once in ten days.

In general, level culture is best. This is secured by plowing one year to the trees and the following year away from them, one year north and south, and the next year east and west. It is somewhat difficult to plow away from large trees, however, and with the cultivators or harrows now in use, it is easy to work the soil away by subsequent cultivation, allowing the furrow to be thrown towards the tree each spring; but it is always advisable, upon fairly level ground, to plow the orchard in opposite directions in alternate years.

The difficulty of working close to the trees has had the effect of encouraging too high pruning. There is a tendency to start tops too high rather than too low, thereby exposing great length of trunk to injuries of sun and wind, and elevating the top beyond the reach of pickers and of sprays. For most trees the

ideal length of trunk is under four feet rather than above it, and implements now in the market allow of this lower training. Trees which have low tops or which hang low with fruit can be reached by separating the halves of any of the double harrows by means of a long doubletree, so that the halves, when adjusted, run from four to six feet from each other. A cut-away harrow rigged in this way will work away the back-furrows from under the trees during the season. All cultivators or harrows with high handles, wheels or levers should be discarded if orchards are worked when the limbs bend low with fruit.

This labor of working about trees is greatly facilitated by the use of harnesses which have no metal projections. There should be no harness with elevated tops, and the turrets on the back-pads should be simply leather loops. The back-pad itself should be reduced to a single wide strap entirely devoid of wadding. Harness of the Sherwood type, with no traces, but drawing by a single chain between the horses, are excellent in orchards, as they require no whiffletrees. Such harness is shown in the cover illustration.

It will now be asked what crops may be grown in the orchard. Grain and hay, never! Any hoed crops may be used for the first few years; but it must be remembered that every crop competes with the trees for food and moisture, and whatever may befall the crop, the trees should not be allowed to suffer. An open space should be left about the tree, free of crops, at least several feet in extent. In fact, this space should correspond with the spread of roots of the tree. Corn and some other plants will appropriate moisture more quickly than can the tree. In orchards set less than twenty feet apart, the land should rarely be cropped after the third year; but apple orchards, if well cared for, may be cropped lightly for seven or eight years. In no case should the grower expect to secure as much crop upon orchard land as upon other areas; and the drier the land, the less should it be cropped. When the orchard comes into bearing age, give it the entire land. Thereafter, the most profitable crop to raise is cultivators!

The growing of nursery stock in orchards—a frequent practice in Western New York—should be discouraged. This crop makes essentially the same demands upon the land as the orchard itself,

and it does not allow of those variations in cultivation and management which may be essential to the varying seasons. It may be true that enough fertilizer can be placed upon the land to replace the loss of plant food, but it is never done and probably never will be. And, more than this, the nursery stock drinks up the moisture which should be used by the orchard. Nursery stock is known to be particularly hard upon land, so much so that nurserymen never grow two crops of fruit-tree stocks in succession upon the same area.

Sod may sometimes be allowed in an orchard if it is closely pastured, but hay should never be cut. Sod lands are not only drier than cultivated ground, but they are favorite breeding places of insects. Borers are particularly bad in grass land. No stone fruits should ever be allowed to stand in sod, and the same may be said of dwarf pears. Apples and standard pears may now and then be seeded with safety, but it is certainly true that, in general, fruit decreases in proportion as sod increases. Very thrifty young apple and pear orchards may sometimes be thrown into bearing by seeding them down for a time, but the sod should be broken up before the trees become checked in vigor. The use of clover and other temporary cover crops as a means of fertilizing the land, is discussed farther on.

Most of the apple orchards in New York are in sod, and growers are always asking if they shall be plowed up. If the growers of apples are satisfied with the crops of the past few years, let the orchards alone; but if it is thought that better crops are desirable, do not hesitate to make an effort to obtain them. It is surprising that the disastrous failures of recent years have not awakened farmers to the necessity of really doing something for their orchards. Now and then an enterprising man makes an energetic attempt and is rewarded, as a future bulletin will show; but the greater number continue to exercise the most thorough-going neglect and to bewail the failure of the crop. Yes, plow the old apple orchard; then fertilize and spray it. Or, if the roots are too near the surface to allow of plowing, harrow it thoroughly when the turf is soft in spring, and continue to work it during the season. If this is not feasible, then pasture it closely with sheep or hogs, feeding the stock at the same time. If this cannot be done, and the orchard is unprofitable, cut it down.

Fertilizers.—Nitrogen, potassium and phosphorus are the elements which need to be applied to orchard lands.

Nitrogen is particularly efficacious in promoting growth. In fact, the amount of growth and the color of foliage are reliable guides for the application of nitrogen. When mature or bearing trees make a foot or more of growth upon all shoots, and when the leaves are of good size and dark color, the orchard probably has enough nitrogen. A free application of nitrogen to such orchards might do more harm than good, in promoting growth at the expense of fruit, or, in the case of some stone fruits, in producing a poorly matured growth which will be likely to suffer in winter. Orchards are grown for fruit, not for forestry purposes. In general, it is better to supply nitrogen by good cultivation—which assists nitrification—and an occasional green-manure crop, than by the application of nitrogenous fertilizers. If the orchard is not growing and is yellowish in foliage, good cultivation—begun early and repeated very frequently—in connection with the use of potash, phosphoric acid and green manures, will commonly correct it. It is probable that lack of moisture is quite as much the cause of the weakness as lack of nitrogen, particularly if the orchard has been in sod. Now and then a tree will be found which fails to respond to ordinary treatment. If the tree is healthy—that is, not attacked by disease or borers—it may sometimes be brought into a vigorous condition by applying to it a light dressing of nitrate of soda; but this treatment need seldom be applied to an entire orchard.

In orchards which are thoroughly tilled, the use of barn manures should generally be discouraged, for the chief element of fertility in them—if they are not leached—is usually nitrogen. This advice is particularly applicable to vineyards, and all other fruits which run very strongly to wood. It is better economy to apply barn manures to the annual crops of the farm. The old neglected apple orchards of the country, however, may receive barn manures with safety; yet, even here it is a question if economy would not dictate tillage and late green manures to supply the nitrogen, except, perhaps, for a season or two when an attempt is making to rejuvenate an orchard. Mulching a sod orchard with manure often gives fairly good results in cases where

the land cannot be cultivated ; but better results in the way of fertilizing and in freedom from weeds and insects can be obtained by pasturing closely with sheep or swine.

Potash is generally the most important element to be applied directly to orchards, particularly after the trees have reached bearing age. The store of available potash in the soil is much increased by the thorough tillage which has already been recommended, but in bearing orchards it should also be supplied every year in some commercial form. One of the best sources of potash for orchards is wood ashes, but this material is so often weakened by leaching that it cannot be confidently recommended. A good sample of unleached hard wood ashes should contain from 7 to 9 per cent. of potash, but much of the commercial article does not analyze above 2 to 3 per cent. Potash in this form has a trade value of $4\frac{1}{2}$ cents per pound. To this value of wood ashes should also be added 2 per cent. or less of phosphoric acid, now worth 6 cents a pound. Forty to fifty bushels to the acre is considered to be a good dressing of wood ashes, if it has been kept dry.

Muriate of potash is perhaps the best and most reliable form in which to secure potash at the present time. Commercial samples generally contain from 80 to 85 per cent. of muriate of potash, or about 50 per cent. of actual potash. Kainit or German potash salts is an impure muriate of potash containing about 12 per cent. of potash. An apple orchard in full bearing and upon loose soil may receive as high as 1000 lbs. of muriate of potash per acre, but a normal and economical application is from 500 to 700 lbs. Sulphate of potash is also thought to be a good form in which to buy potash. The commercial article will analyze 50 per cent. or less of actual potash. Sylvanite is a cheap and low grade of this material which is often bought by farmers as sulphate of potash. Its value—like that of other materials mentioned—should be reckoned upon the amount of potash present.

Phosphoric acid may be obtained in the form of a high grade plain superphosphate (dissolved South Carolina rock), in bone compounds, and Thomas slag. The plain superphosphate contains about 16 or 18 per cent. of phosphoric acid, and 300 to 500 lbs. per acre is a liberal and very useful dressing for bearing orchards.

The bone fertilizers are always valuable. Those which are untreated give up their phosphoric acid slowly, unless they are very finely ground. Dissolved bone gives more immediate results. Thomas or basic slag, which is yet scarcely in the market in this country, has given good results in many tests, but it parts with its fertility very slowly. It is yet too early to recommend this material for orchards with full confidence.

In general, phosphoric acid is rather less important in fruit plantations than potash, although this order is reversed in general farming. Potash should undoubtedly be the leading factor in orchard fertilizers, and nitrogen, as I have said, may be obtained mostly by means of tillage and green crops. It will then be seen that the use of combined or "complete" commercial fertilizers may not be economical. The best results are to be expected when the fruit-grower observes closely the behavior of his trees and then applies such materials as they appear to need. Any of the materials mentioned in the foregoing remarks may be mixed together, so that the phosphorus and potassium can be applied at the same sowing. It should be said, however, that if wood ashes is mixed with a nitrogenous fertilizer, some loss of nitrogen may ensue, unless the material is used at once.

Cover crops and green-manuring.—A sowed crop in the orchard may be valuable in two ways: by affording a cover to the land, and by improving the soil when it is plowed in. As a cover, it may keep down weeds, and protect the land from injurious effects of frost. As a green manure, it may add fibre to the soil and thus augment its power of holding fertility and moisture, and it may add directly to the fertility of the land. This late crop catches and holds the leaching nitrates which the tree-roots utilize earlier in the season.

As a rule, crops grown for cover alone should be sown not earlier than midsummer. The most thorough tillage can then be given early in the season, and the benefits of the cover can be secured for the early fall and winter. It is generally advisable to grow a crop which answers for both a cover and green manure, although it is easily possible to make the soil too nitrogenous for some fruits by the extravagant use of such fertilizer.

There is much confusion in the popular mind concerning the

relation of cover crops to moisture. Some contend that any crop which shades the ground, will keep the surface moist and conserve moisture, whilst others, knowing that all plants exhale water, consider that any crop tends to make the land dry. Both these opinions are partly correct. A crop which occupies the soil the entire season and which does not allow of cultivation will make the land dry, whilst one sowed late in the season upon land which has been thoroughly tilled during May, June and July, will not seriously rob the soil of moisture. At all events, there need be no fear of drying out the soil by sowing a late crop, for the serious injury of drouth is usually effected before such crops are established ; and the tree needs to be checked, rather than stimulated, at this season, by the transfer of the nitrates and moisture to other plants. The most marked way in which such crops conserve moisture is by means of the fibre and humus which they impart to the soil when plowed under ; but even this humus cannot compete with cultivation as a retainer of moisture.

An experiment now continuing in one of our orchards illustrates the value of cultivation over green manuring alone, in this dry year. The orchard is a hard clay,—just the soil which is benefitted by the loosening effects of green manures. The orchard was divided into three portions in 1890, a year after the trees were set. One-third has received liberal annual dressings of commercial fertilizers,* and has been well tilled ; another third has had no treatment except good tillage ; and the remaining third has had liberal applications of potash and has then been sown early to a nitrogenous (leguminous) green crop. This third portion has simply been plowed and fitted well each spring, and then sown, having received no subsequent tillage. The crops were all plowed under the following spring. The following are the crops :

- 1890. Mixed beans. Sowed June 16.
- 1891. Field peas. Sowed June 24.
- 1892. Vetch. Sowed June 16.
- 1893. Cow peas. Sowed June 19.
- 1894. Field peas. Sowed June 14.

*This experiment has not yet progressed far enough for report upon methods of fertilizing, and is mentioned here only for the purpose of contrasting methods of cultivation.

Here, then, is a chance to compare the effects of tillage with humus in a season of almost unprecedented drouth. At this writing (Sept. 1) the green manured strip is much the driest portion of the orchard. The tree growth in this portion is much less vigorous and the leaves perceptibly lighter colored than on the adjacent plots. Even the unfertilized but well tilled tract shows a better foliage. In this green manure portion, leaves on peach trees are now beginning to yellow and fall from the effects of drouth, whilst the same rows, when they strike the other plots, show perfect foliage. In apricots the effects are also marked. Pears and plums also show the differences. In the cultivated portions one can easily stir up loose earth with the toe of his boot, while in the green manured part one has to dig from six to ten inches in a hard soil before he can find visible moisture. Careful tests show the same fact. Samples of soil were taken to the depth of 1 foot on September 1, by means of a soil sampler, eight samples being lifted from representative parts of both the tilled and untilled areas. Four of these samples were combined into one, and this mixture constituted the complete sample which was used in a test for moisture: that is, there were two samples of untilled soil and two of tilled soil, but each of these was made up of four other samples selected from various parts of the areas. These samples were carefully weighed and were then equally fire-dried and weighed again. The loss in weight represents the comparative content of free water in the different samples. The results are as follows:

	Sample I.	Sample II.
Moisture in tilled soil,	11.3	12.8
Moisture in untilled soil,	8.7	9.6

In addition to this difference in moisture between the two areas, it should be said that in the tilled land it was distributed to within two inches or less of the surface, while in the untilled land the first few inches was exceedingly dry. In other words, in the tilled land nearly the entire soil was in condition to part with its fertility, while in the other the uppermost and richest soil was inactive.

All this emphasizes the fact that tillage alone is better than green manuring alone. But the best results would no doubt have

been obtained if good tillage had been given for two or three months, and if the green crop had been sown in August or September. In general, I believe this combination to be an excellent one for orchards, particularly for such lands as lack nitrogen and vegetable matter, and for those fruits which, like peaches, are benefitted by some winter protection of the soil. Walter F. Taber, of Poughkeepsie, one of the most careful horticulturists in the state, gives me this bit of experience, under date of August 30, which is suggestive in this connection: "Dry is no name for it here, but my place does not show it like many others. I have two fields which show how moisture can be held in the soil. One is a strawberry setting of one and one-fourth acres, made upon a heavy growth of rye plowed under April 26 and 27, and the ground worked fine and rolled May 10, and set the 11th and 12th. The other is one and seven-eighth acres of sweet corn. This piece was seeded with clover and turnips last August and September, and the whole growth of both clover and turnips was plowed under May 15 and 16, and the land was planted to sweet corn May 29 and 30, after receiving a dressing in alternate strips of Compound Corn Manure and muriate of potash. Both these pieces are upon black soil which has burned up in former years with a less severe drouth than at present; but now my black soil is doing best." Our own orchards have withstood the drouth wherever well tilled; and the same is true wherever I have been in Western New York. But the neglected orchards are suffering.

It will now be asked what is the best plant for cover and green manure. It is hard to tell. Clover is the stand-by, but it is generally difficult to obtain a good "catch" late in the season, and it should stand on the land an entire season in order to obtain its full value. Upon good and well-tilled lands and in favorable seasons, considerable herbage can be obtained for turning under in the spring if it is sown the preceding August or September; but in general it is unreliable as an annual crop.

Vetch answers the purpose admirably in many respects, as shown in our bulletins 49 and 61, and I think that it is the best all-around cover crop yet proved in New York State. It is killed by the winter, however, and it therefore takes no advantage of the early days of spring. But this fact is in its favor for some

occasions, because it encourages very early plowing. It must also be sown too early in the season for best results with tillage. It should be sown not later than the middle or last of July in this latitude. It affords an excellent winter cover for the soil, and it is rich in fertilizer value. It should be sown at the rate of a bushel of seed to the acre. Seed can be obtained of the leading seedsmen.

Rye is a favorite cover crop in peach orchards, chiefly because it grows well upon light soils and can be depended upon to make good growth with the most indifferent preparation of land. It contains very little fertilizing value, however.

Cow peas are nearly worthless in this state, as shown in Bulletin 61, as they are killed by the first frost and must therefore be sown very early if growth of any consequence is obtained. The leaves also fall when the plant is frosted, and the land does not receive so much protection as it does from other plants.

Common field beans are open to much the same objection as the cow pea, although the season of growth is short. We used them in 1890 on a portion of one of our orchards, but concluded that they were unprofitable as a cover crop.

Field peas are excellent for fall sowing in orchards. Last year a sowing of peas made on August 18, made vines two to three feet long and completely covered the ground.

But I am looking to the crimson clover as the coming orchard cover and green manure, although it is not yet positively determined just how well it will endure our winter. We made a sowing of it late in the summer of 1893. The "catch" was very poor, but what plants we obtained endured the winter and grew vigorously this spring. In New Jersey, as stated in Bulletin 100 of the Experiment Station of that state, the following points, amongst others, are now considered to be established:

"Crimson clover is an annual plant, hardy for the whole state; it has been successfully grown in every county from Cape May to Sussex. It is adapted for a wide variety of conditions, both in reference to character of soil, and method and time of seeding, though not as a substitute for red clover."

"Crimson clover may be seeded in orchards, berry patches, corn, tomatoes, etc., and upon raw ground following after pota-

atoes, tomatoes, melons or other crops harvested before September. It is not adapted for seeding with wheat or rye."

"The amount of seed may range within wide limits—8 to 16 pounds per acre; larger amounts are usually required when sown with other crops, and smaller amounts when sown upon raw ground or in orchards. Twelve pounds per acre will doubtless be found to be sufficient."

"No failures to stand the winter have been reported when good, American-grown seed was used. It is more hardy than red clover. Foreign seed has not proved satisfactory. It contains as impurities weed seed and less hardy varieties of this clover. The seed is not as yet produced in any considerable quantity in this state. That used in our experiments was raised in Delaware, where the business of seed-growing is assuming considerable proportions and is reported to be profitable."

"Regarded as a green manure, particularly as furnishing nitrogen derived from the air, this crop possesses many advantages due to its time of growth and development."

"Good crops of this clover can be obtained on naturally poor or worn-out lands when fertilized with the mineral constituents only; these soils are rapidly improved by the addition of the nitrogen and accompanying organic matter contained in the crop."

"This plant provides a good pasture before other crops are available. An early pasture is not only valuable for the food contained in it, but also because it helps to insure proper feeding and to prevent too early use of other and later pastures. It was pastured this year in central New Jersey as early as April 10th. The crop when six inches high contained over 1,300 pounds of digestible food per acre, sufficient to properly nourish twelve cows for one week."

"The fertilizing value per acre of the residue in the roots, is equivalent in nitrogen and organic matter to that contained in three tons of city manure."

In Chautauqua County, crimson clover was sown last year by G. Schoenfeld, of Westfield, whose success with it has led to a general trial of the plant in that vicinity. Mr. Schoenfeld gives this account of his experiment :*

* Grape Belt, Aug. 3, 1894.

"A year ago last June I procured a bushel of American grown seed, which I sowed the 22d and 23d of August in different spots in the vineyard, at the rate of 20 pounds to the acre. A vineyard of one and one-half acres, heavy brick-clay, was sown entirely. On account of the protracted drouth at that time, it was three weeks before it came up and it was what is called a poor stand, and I was also disappointed that it did not make a better growth before winter set in. But it wintered well, which settled the only point that I was in the least doubtful on,—if it can be grown in Chautauqua county—and on which point I was unable to get any information. The lack of growth in the fall was made up the following spring, and on the 10th of May the plants averaged 15 inches in height and were in full bloom. The first week in June the crop was turned over with a Rochester gangplow."

D. R. Pease, Trumansburg, Seneca County, has also had experience with crimson clover. He writes me as follows: "I sowed a small piece August 25, 1893. It made some growth in the fall and went through the winter in good condition. It began to grow as soon as the frost was out of the ground last spring, and by May 1st was a heavy crop. I allowed it to ripen and saved the seed, which I sowed September 1, 1894. I am well pleased with it, and think that it will prove valuable as a mulch."

ABRIDGEMENT.

If orchards are to be made profitable, they must receive as good care as other crops.

Good drainage, natural or artificial, is essential to success. Trees are impatient of wet feet.

Well drained lands are drier in wet spells and moister in dry spells than other lands. They can be worked earlier in spring.

Good tillage increases the available food supply of the soil and also conserves its moisture.

Trees should be made to send their roots deep into the soil, in order to fortify themselves against drouth. This is done by draining the soil and by plowing the orchard rather deep.

This deep plowing should begin the very year the trees are set and it should be continued every spring until the habit of the trees is established.

Moisture is retained in the upper soil by very frequent but shallow tillage, by means of which the surface of the land becomes a mulch for the soil beneath.

Tillage should be begun just as soon as the ground is dry enough in spring.

This tillage should be repeated as often as once in ten days throughout the growing season, which extends from spring until July or August.

Tillage should not exist for the purpose of killing weeds. Weeds have taught the most important lesson in agriculture, to be sure, but the schoolmaster should now be able to retire.

Late cultivation may be injurious by inducing a late growth. At all events it can be of small utility when the tree begins to mature and rains become frequent. This season of respite gives the grower the opportunity of raising a green manure, and of adding fertility to his land at trifling expense and with no harm to his trees.

Fall plowing may be advisable for farm crops, but it should generally be discouraged in orchards. The land in orchards should be left compact in the fall, and it is advisable to cover it with some close herbage.

Only cultivated crops should be allowed in orchards early in the season. Grain and hay should never be grown.

Nursery stock should not be grown in orchards.

Even hoed or cultivated crops may rob the trees of moisture and fertility if they are allowed to stand above the tree roots.

Cultivators is the best crop to raise in an orchard.

Sod is sometimes allowable in apple and standard pear orchards, but never in other fruit plantations; but even then it should be pastured closely with sheep or hogs. If the stock is fed at the same time, the land will fare better.

Watch a sod orchard. It will begin to fail before you know it.

Probably nine-tenths of the apple orchards of New York state are in sod, and many of them are meadows. Of course they are failing.

The remedy for these apple failures is to cut down many of the orchards. For the remainder, the treatment is cultivation, fertilizing, spraying,—the trinity of orthodox apple-growing.

In general, level culture is best. The modern cultivators and harrows make such cultivation easy.

Trees, especially apples, are often trained too high, because of the difficulty of working close to them. Modern tools will bring the heads within reach.

Harnesses with no projecting hames nor metal turrets should be used in bearing orchards. Those requiring no whiffletrees are also useful.

Potash is the chief fertilizer to be applied to fruit trees, particularly after they come into bearing.

Potash may be had in wood ashes, and muriate ~~sulphate~~ of potash. It is most commonly used in the latter form. An annual application of potash should be made upon bearing orchards. Of the muriate from 500 to 700 pounds may be used to the acre in mature orchards.

Phosphoric acid is the second important fertilizer to be applied artificially to orchards. It may be got as plain high-grade superphosphate (dissolved South Carolina rock), in the bone fertilizers, and perhaps in Thomas slag. Of the plain superphosphates, from 300 to 500 lbs. may be applied to the acre.

Nitrogen can be obtained cheapest by means of thorough tillage (to promote nitrification) and nitrogenous green manures. There is rarely occasion for buying it for fruit plantations, if the lands are properly tilled and cropped.

Nitrogen promotes growth. It should therefore be used with some caution, for orchard trees should be grown for fruit rather than for timber.

Barn manures are generally more economically used when applied to farm crops than when applied to orchards; yet they can be used with good results, particularly when rejuvenating old orchards.

In general, the commercial complete fertilizers are less rational for orchards than a fertilizer made for the occasion out of materials evidently needed by the trees; but the complete fertilizers give much better results than the prevailing indifference and neglect.

Cultivation may be stopped late in the season, and a crop can then be sown upon the land. This crop may serve as a cover or protection to the soil and as a green manure.

A green manure improves the soil by adding fibre to it and by increasing its fertility. It catches the nitrates which, earlier in the season, are used by the tree-roots. Vegetable fibre in the soil increases its power of holding both moisture and plant food.

The crops well adapted to this late sowing are few. Vetch is probably the best which has been well tested in the State. But everything points to crimson clover as the ideal orchard cover and green manure.

The gist of it all is that orchards should be cultivated and fed. Cultivation should begin early and be continued often. It may be stopped in August if the grower thinks best, and then, if the land needs it, a green crop may be sown for turning under the next spring.

L. H. BAILEY.



In answer to many inquiries concerning the prices of fertilizing materials, it may be said that muriate of potash costs \$40 and upwards per ton, sulphate about \$48, dissolved boneblack about \$24, ground bone about \$30, kainit about \$13, and nitrate of soda, $2\frac{1}{4}$ cents per lb. These prices vary, of course, with the composition or mechanical condition of the materials. The average composition of unleached ashes in the market is as follows : potash, 5.25 per cent. ; phosphoric acid, 1.70 per cent. ; lime, 34 per cent. ; magnesia, 3.40 per cent. The average composition of kainit is 13.54 per cent. potash ; 1.15 per cent. lime. The composition of sylvinite (which is said to be known as sulphate of potash in some quarters) is about 16 per cent. of potash, in the form of both muriate and sulphate, mostly the former. The fact that "the soil itself is the greatest storehouse of plant food," as stated on page 297, is shown by the following average of 35 analyses of the total content of the first eight inches of surface soils, per acre : 3,521 lbs. of nitrogen ; 4,400 lbs. of phosphoric acid ; 19,836 lbs. of potash. Much of this is unavailable, but the good tillage which has been recommended tends to unlock it. The amount of fertilizing material which should be added to the soil for economical results, must depend very largely upon the kind of cultivation, the crop, and previous treatment. If a bearing orchard, for instance, receives an application of potash every year, from 200 to 300 lbs. of muriate of potash per acre will afford an economical dressing ; but in those which have had indifferent care, a larger application may be made, as recommended on page 304.

17
1894
Bulletin 73.

September, 1894.

Cornell University Agricultural Experiment Station.

BOTANICAL DIVISION.

LEAF CURL AND PLUM POCKETS.

**CONTRIBUTION TO THE KNOWLEDGE
OF THE PRUNICOLOUS EXOASCEÆ OF THE
UNITED STATES.**



By GEO. F. ATKINSON.

PUBLISHED BY THE UNIVERSITY,

ITHACA, N. Y.

1894.

ORGANIZATION.

BOARD OF CONTROL:

THE TRUSTEES OF THE UNIVERSITY.

STATION COUNCIL.

President, JACOB GOULD SCHURMAN.

Hon. A. D. WHITE,	-	-	-	-	Trustee of the University.
Hon. JOHN B. DUTCHER,	-	-	-	-	President State Agricultural Society.
Professor I. P. ROBERTS,	-	-	-	-	Agriculture.
Professor G. C. CALDWELL,	-	-	-	-	Chemistry.
Professor JAMES LAW,	-	-	-	-	Veterinary Science.
Professor A. N. PRENTISS,	-	-	-	-	Botany.
Professor J. H. COMSTOCK,	-	-	-	-	Entomology.
Professor L. H. BAILEY,	-	-	-	-	Horticulture.
Professor H. H. WING,	-	-	-	-	Dairy Husbandry.
Professor G. F. ATKINSON,	-	-	-	-	Cryptogamic Botany.

OFFICERS OF THE STATION.

I. P. ROBERTS,	-	-	-	-	-	Director.
E. L. WILLIAMS,	-	-	-	-	-	Treasurer.
H. W. SMITH,	-	-	-	-	-	Clerk.

ASSISTANTS.

M. V. SLINGERLAND,	-	-	-	-	-	Entomology.
GEO. C. WATSON,	-	-	-	-	-	Agriculture.
G. W. CAVANAUGH,	-	-	-	-	-	Chemistry.
E. G. LODEMAN,	-	-	-	-	-	Horticulture.
MICHAEL BARKER,	-	-	-	-	-	Horticulture.

Office of the Director, 20 Morrill Hall.

Those desiring this Bulletin sent to friends will please send us the names of the parties.

BULLETINS OF 1894.

62. The Japanese Plums in North America.
63. Co-operative Test of Sugar Beets.
64. On Certain Grass-Eating Insects.
65. Tuberculosis in Relation to Animal Industry and Public Health.
66. Test of Cream Separators.
67. Some Recent Chinese Vegetables.
68. The Cultivated Poplars.
69. Hints on the Planting of Orchards.
70. The Native Dwarf Cherries.
71. Apricot Growing in Western New York.
72. The Cultivation of Orchards.
73. Leaf Curl and Plum Pockets.

LEAF CURL AND PLUM POCKETS.

CONTRIBUTION TO THE KNOWLEDGE OF THE PRUNICOLOROUS EXOASCEÆ OF THE UNITED STATES.

The distortions of the leaves of the genus *Prunus* known popularly as leaf curl, and the hollow, spongy, abnormally enlarged fruits commonly called "plum pockets," or "plum bladders," are caused by certain fungi belonging to the family *Exoasceæ*. The *Exoasceæ* are composed largely of parasitic species which live upon many of the higher plants and are especially abundant upon the *Rosaceæ*. The family is characterized by the possession of fruit structures, termed asci, which are approximately cylindrical and stand, more or less crowded together, out upon the surface of the affected portions of their hosts.

Several attempts have been made to establish genera for what seemed to be natural divisions into which the members of the family grouped themselves. These genera were based principally upon the number of spores in the ascus. The known spore characters, however, in this family are so remarkably inconstant that nothing more than an unsatisfactory artificial classification has thus far been proposed upon that basis. Sadebeck* has recently proposed a more natural subdivision of the parasitic *Exoasceæ*. Those species in which the asci are not developed from a common subcuticular hymenium, but from the ends of intercellular hyphæ are made the ground for a new genus, *Magnusiella*. This genus is represented in the United States by the well known *M. potentillæ*† (Farl.) Sadeb., upon *Potentilla canadensis*. Those species

* Die parasitischen Exoasceen. Eine Monographie. Abgedruckt. a. d. Jahrbuch d. Hamb. Wiss. Anstalten. x. 2. Hamburg, 1893.

† *Exoascus deformans* (Berk.) Fuckel var. *potentillæ* Farlow, Proceedings Amer. Acad. Arts and Sciences, XVIII, 1883, p. 84. *Taphrina potentillæ* Johanson, Oefvers. af Kgl. Vet.-Akad. Forh. 1885. *Magnusiella potentillæ* Sadeb. Abgedr. a. d. Jahrb. d. Hamb. Wiss. Anst. x. 2. 1893, p. 86.

in which the asci are developed from a common subcuticular hymenium are farther divided into two genera. Those with a perennial mycelium are placed in the Fuckelian genus *Exoascus*, while those lacking a perennial mycelium are placed in the Friesian genus *Taphrina*. *Taphrina* as thus emended contains species in which a new infection each year is brought about by spores. A common representative of the genus in this country is *T. coerulescens** (Mont. et Desm.) Tul. The species of *Exoascus* having a perennial mycelium, a new infection each year is secured by the mycelium which winters over in the tissues of the host, and by the spores.

The prunicolous species of *Exoasceæ* thus far known all belong to the genus *Exoascus*. These have for the present purpose the chief interest and farther discussion of the other two genera is not contemplated here.

Considerable material has accumulated during a period of observation extending over five years, which seemed to justify the preparation of the matter for publication. Especially does this seem to be the case since no comprehensive illustrated account of those species occurring on the stone fruits in the United States has as yet been attempted. The economic importance of the stone fruits suggested the appropriateness of presenting the contribution as a bulletin for the information of fruit growers, since a knowledge of the known characteristics and mode of perpetuation of the parasites will aid those interested in checking or preventing the injuries.

In making a critical examination of the material at hand it appeared that there were several well characterised undescribed species, a fact which was not anticipated at the outset. This is a sufficient explanation of the necessary use of much technical description in a portion of the paper.

No part of the plant is exempt from the attacks of these fungi except the roots. The first marked effects of their active presence in the tissues of the host is the stimulus to an increase in the number or size of the cells so that characteristic malformations of the diseased parts appear. In the leaves the increase in the num-

* *Ascomyces coerulescens* Mont. et Desm. Ann. d. Sci. Nat. Bot. ser. 3, x. p. 345. *Taphrina coerulescens* Tulasne, Ann. d. Sci. Nat. Bot. ser. 5, v. p. 127.

ber of the cells of the diseased portion causes that part of the leaf to arch upward or downward in a series of irregular folds, or a somewhat circular spot becomes strongly arched in one direction forming a deep, wide mouthed pocket. The twigs become enlarged in diameter and variously contorted, or an early development of the buds is stimulated producing what are commonly called "witches brooms." The fruit becomes transformed into a large spongy mass of tissue, which is hollow and devoid of the "stone" or "pit;" or only one side of the fruit is affected when irregular one sided swellings of similar tissue are developed. The floral envelopes in some species partake also of the hypertrophy, and in other cases only the superficial portion of the fruit is affected when the "stone" is normally developed. In the latter case sometimes a warted condition of the fruit appears. The young leaf buds of some species are transformed into a large spongy hollow mass, much resembling in texture the tissue of the "plum pockets." A number of these characteristic hypertrophied parts of various plant organs are illustrated in photographic reproductions in Plates I-X.

Mycelium. In all of the species at present known on the genus *Prunus*, with one exception,* the mycelium penetrates to some depth in the tissues, but it is always intercellular. It is quite characteristic and can usually be readily differentiated from the mycelium of other fungi when examined in situ. It is very irregular in its course and the size of its cells. These are cylindrical, oblong, clavate, or oval, and are joined in an irregular chain without order between the cells of the host. The mycelium may be quite abundant in some species so that when the other intercellular substances and portions of the cell walls of the host are dissolved out by the use of chloral hydrate, and differentiated by the use of some of the stains like eosin, it presents a very intricate network of threads. In other species or in parts of the plant not so seriously affected, or in parts where the mycelium is passing over the winter, it is more scanty, frequently consisting of isolated, oval or irregularly oblong cells.

* *Exoascus minor* Sadebeck, Kritische Untersuch. ü. d. durch Taphrina-Arten hervorgebr. Baumkrankheiten. Abgedruck. a. d. Jahrb. d. Hamb. Wiss. Anst. VIII, 1891, p. 24.

Hymenium. From the interior of the tissues the mycelium grows to the surface and spreads, by branching, out over the epidermal cells just beneath the cuticle. The cells of the subcuticular layer soon become nearly isodiametric and are usually developed in such numbers that eventually they are closely crowded, when they become angular in outline. By a less profuse development they may appear as variously branched chains of oval cells. These subcuticular cells are very rich in protoplasm, much more so than the cells within the tissue. They make up what is called the hymenium. In figure 81 is shown a section of a portion of a deformed bud of *Prunus angustifolia* presenting the intercellular-mycelium and young hymenium of *Exoascus mirabilis* Atkinson. In fig. 83 is represented a surface view of a portion of the hymenium of the same species.

Each of the cells of the hymenium elongates perpendicularly to the surface, forming cylindrical or clavate cells which divide by a septum into two cells, the septum usually being near the base. The inner cell is the stalk cell while the outer cell is the ascus or fruiting cell. In each ascus there are developed a variable number of spores, usually four or eight. These are rounded, oval, or elliptical in form, and are colorless. At normal maturity a perforation usually occurs at the apex of the ascus and the spores are ejected with considerable force. The ascus becomes turgescient by endosmosis, this produces a pressure upon the walls and a rupture occurs at the weakest point, which is at the apex. De Bary* says that the ejection of the spores takes place in a manner exactly similar to that in various species of other Discomycetes which he examined. I have several times watched under the microscope the expulsion of the spores of some of the Discomycetes like *Dasyscypha virginea* (Batsch) Fuckel, *Propolis faginea* (Schrad.) Karst. *Trichopeziza capitata* (Peck) Sacc., and others. In the Pyrenomycetes I have watched the same phenomenon in the case of *Spherella pyri* Auersw. By mounting specimens which are not too old in fresh water and immediately noting the asci under the microscope they can be seen to become turgesc-

* *Exoascus pruni* und die Taschen oder Narren der Pflaumenbäume, Beiträge z. Morph. u. Phys. d. Pilze, Erst. Reihe. Abgedruckt. a. d. Abhandl. d. Senkenb. Naturf. Gesellschaft, Bd. V, pp. 183 and 184, Frankfurt, 1886.

cent and finally a rupture occurs at the apex and the spores are shot out suddenly. Usually the spores are all shot out together from a single ascus. De Bary* and Rathay† both placed freshly gathered specimens of *Exoascus* on a glass slip in a moist atmosphere and after several hours the glass was covered a distance of 1 cm. from the specimen with the spores, which formed a white ring around it.

When the fungus is mature the affected parts of the plant present a whitish or mealy aspect caused by the numbers of asci and free spores.

Each spore in water or in nutrient solutions is capable of producing, by a process of budding similar to that of the yeast plant, smaller and similar cells. In water the parent spore becomes by this process smaller also. This frequently takes place within the ascus when the spores are not expelled at maturity, so that after a while the ascus is quite well filled with these small conidia. DeBary,‡ Brefeld§ and Sadebeck|| record the results of attempts to grow the spores in artificial media. In no case was a mycelium observed to develop, but budding always took place where any growth appeared. By placing spores on the young leaf buds, or better on the leaves of seedlings, Sadebeck¶ succeeded in observing the entrance of a mycelium in the leaves of *Alnus*. The species experimented with was *Exoascus tosquinetii* (Westend) Sadeb. The mycelium was observed to enter through the stomata into the tissues.

We can now enter into a more detailed discussion of the hyper-

* Ibid.

† Ueber die Hexenbesen der Kirschbäume, und *Exoascus wiesneri* n. sp. Sitzungsab. d. Math.-Naturw. Classe d. k. Akad. d. Wiss. Bd. LXXXIII, Abth. I, p. 280, Wien, 1881.

‡ *Exoascus pruni* etc. Beiträge z. Morph. u. Phys. d. Pilze, Erst. Reihe, Abgd. a. d. Senkenb. Naturf. Ges. Bd. V. pp. 185, 186; 1886.

§ Unters. a. d. Gesamtgeb. d. Mykol. Heft IX, pp. 142, 144, Münster, 1891.

|| Die parasitischen Exoasceen. Abdruck. a. d. Jahrb. d. Hamb. Wiss. Anst. X, 2 p. 13; 1893.

¶ Unters. ü. d. Pilzgattung *Exoascus* und die durch dieselbe um Hamburg hervorgerufen Baumkrankheiten. Abdruck. a. d. Jahrb. d. Wiss. Anst. p. 102; 1883. Hamburg.

Die parasitischen Exoasceen. Ibid. X, 2, p. 13; 1893.

trophied organs of the various species of *Prunus*, and the morphology and structure of the infecting species of *Exoascæ*.

PRUNUS PERSICA (L.). Peach.

Exoascus deformans (Berk.) Fuckel.

The leaves and twigs are the only portions of the peach tree which are at present known to be affected with the fungus. The leaves are more commonly the place for the injury to be shown, and the twigs are but rarely attacked seriously or so as to attract attention. During June, 1894, I observed a tree on the Cornell University Campus having the leaf "curl" and a few of the ends of certain twigs were abnormally enlarged, though but slightly. One of these is reproduced from a photograph in Plate I, Fig. 1. The petioles of the leaf are also hypertrophied and profusely corrugated. From the petioles the hypertrophy can be seen to extend part way on the stem. Scribner* notes quite a serious injury to young shoots of nursery trees received from New York and transplanted at Knoxville, Tenn. The shoots for several inches below the leaf bud were considerably enlarged and presented a very much roughened or corrugated surface.

The disease in the leaves produces the distortions which are commonly spoken of as "leaf curl." With the increase in the number and size of the cells of the affected part the leaf is thrown into a series of irregular folds frequently transversely to the long axis of the leaf. Sometimes the arching of the leaf takes place more strongly on one side than on the other when a strong convexity appears on that side. When a large portion of the leaf is thus affected it frequently bulges out on one side along the middle and the edges of the leaf are drawn toward each other, the leaf appearing as if strongly inflated. In the affected portions of the leaf the green color pales and the parts are more or less brightly colored with reddish or yellowish tints. The leaf tissue at these parts is also thickened and assumes a "cartilaginous" consistence. The parenchyma cells are frequently very much elongated and curved or sinuous in form. The mycelium is perennial in the leaf buds, that is, it passes the late summer, autumn and winter months in the tissue of the leaf buds and in

* Fungus diseases of the grape and other plants, p. 126. 1890.

the following spring grows out with the developing leaf, multiplying more abundantly in certain portions than in others at times. This accounts for the fact that the whole area of the leaf is not at all times affected.

The persistence of the mycelium during the autumn and winter seasons in the leaf buds is probably the chief cause of the spread of the disease. When buds are taken for "budding" young seedlings in the nursery, if they are taken from an affected tree the disease is quite sure to be transmitted to every young tree which is started from a bud which contains the perennial mycelium. Since all of the affected leaves fall off from diseased trees at quite an early period, and at the time of budding the seedlings in August there is probably no sign of the curl in any of the leaves, it would be impossible to discriminate between the diseased and healthy trees, or the affected and free branches. An early selection of healthy trees for budding purposes would prevent the transmission of the disease through nursery stock.

Some experiments have been made in various places by spraying the trees with the Bordeaux mixture for the prevention of the leaf curl of peach trees. Some of the experimenters regard it as certain that the disease can to some extent be checked by this method. It is quite likely that, in some cases at least, another disease is confused with the leaf curl, and this fact might account in those instances for the results claimed. More definite experiments with an accurate determination of the diseases present should be made before too much can be claimed for the efficacy of the application of sprays for the prevention of this trouble.

The asci are developed on both surfaces of the leaf. Before the young asci pierce through the cuticle in their development they frequently raise the cuticle somewhat when it appears on drying as a thin whitish glistening membrane. The asci are nearly cylindrical, sometimes slightly clavate, and rounded or truncate at the free ends. They measure 25*-40 long by 8-11 in diameter, the larger number possessing intermediate measurements and being 30-35 by 9-10. The stalk cells are 6-8 high and 6-9 or 10 in diameter. They frequently taper considerably

* Measurements where not otherwise stated are given in terms of the micromillimeter.

toward the base and often are quite sharp pointed. Occasionally where they are not much crowded the stalk cell is considerably broader, attaining a diameter quite equal to that of the ascus at its distal end, while it will be broader than the lower end of the ascus. The pointed ends of the stalk cells frequently intrude somewhat between the cells of the epidermis.

The number of spores in an ascus is usually eight or approximately that number. They are rounded or oval and measure 3-4 in diameter. Sometimes the number is quite constantly four in a large number of asci and then the diameter is considerably greater, reaching 5 or 6. Asci with only four spores were found by me quite frequently on specimens of peach leaves distributed in Seymour and Earle's Economic Fungi, Fasc. I No. 14, and collected in Temple, N. H., June 18, 1888. A few of these are illustrated in fig. 21. Sadebeck* records the same variation in the case of *Exoascus epiphyllus*, *E. farlowii*, *Taphrina ulmi*, *T. bullata*, and others. Brefeld† suggested that according to the custom of some authors in using the number of spores as a basis for the separation of genera that the four spored *Exoasceæ* should be separated from the eight spored ones. Eight spored asci, however, present very great variations in a number of Ascomycetes so that in asci from the same perithecium there may be four, six or eight spored asci. Several species of *Teichospora* may be cited as examples of this.

PRUNUS AVIUM L. English Cherry.

Exoascus cerasi (Fuckel) Sadeb.

This species, *Exoascus cerasi* (Fuckel) Sadeb. has been found on "escaped cherry trees" at Germantown, Pa., by Prof. Thomas Meehan. It was distributed in Ellis, N.A.F. No. 2286, as *Exoascus wiesneri* Rathay.

This fungus forms the well known "witches brooms" of *Prunus avium* and *P. cerasus* in Europe. The mycelium is perennial in the affected twigs, the fructification only showing upon the leaves. In response to an inquiry Professor Meehan writes that

* Die parasitischen Exoasceen. Abgedruck. a. d. Jahrb. d. Hamburg. Wiss. Anst. X, 2, pp. 8-9. 1893.

† Unters. a. d. Gesamt. d. Mykol. IX, p. 144, Münster, 1891.

the twigs are not deformed, but instead of forming spurs, or flower buds, as in ordinary branches, twigs are produced and this gives the broomy appearance. The presence of the mycelium thus stimulates an early and profuse development of twigs so close together that it roughly stimulates a broom. The asci in the specimens which I have seen occur on the under side of the leaf, though Robinson* says they occur on both surfaces. The leaf is deformed, presenting a series of folds and wrinkles, and the fructification shows as a dense whitish layer on the surface. The fungus was first described by Fuckel† as *Exoascus deformans* b, *cerasi*. Rathay‡ made a critical study of the perennial mycelium and the peculiarities of the infected branches, and named the fungus *Exoascus wiesneri*. It has been considered by many as only a form of *Exoascus deformans* (Berk.) Fuckel, and Robinson|| refers it to that species though he notes that the asci are much more slender than those of the typical form on the peach, the stalk cells proportionately much longer and they do not taper below as in that species. Sadebeck§ regards it as a distinct species but accepts the varietal name given it by Fuckel and writes it *Exoascus cerasi* (Fuckel) Sadeb. It appears to me that it is well distinct from the species on the peach.

The asci are cylindrical and rounded or truncate at the free ends. According to Sadebeck¶ in the European specimens they measure 35-50 long by 7-10 in diameter. He remarks that there is great variability in the size of the asci. In the specimens from Germantown, Pa., which I have seen the asci measure 25-33, long by 6-9 in diameter. The stalk cells 10-17 high by 5-7 in diameter. The more common length for the asci is about 30. The spores are approximately eight in an ascus, and are round or oval. The details of the asci and spores are shown in fig. 25.

*Notes on the genus *Taphrina*. Ann. Bot. I, p. 169, 1887-8.

†Symb. Mycol. p. 252, 1869.

‡Ueber die Hexenbesen der Kirschbäume und über *Exoascus wiesneri*, n. sp. Sitzungsber. d. Math. Naturw. Classe d. k. Akad. d. Wiss. Bd. LXXXIII, Abth. I, p. 267, Wien, 1881.

||Notes on the genus *Taphrina*. Ann. Bot. I, p. 168-169, 1887-8.

§Kritische Unters. über die durch *Taphrina*-Arten hervorgebrachten Baumkrankheiten. Abgedruckt. a. d. Jahrb. Hamb. Wiss. Anst. VIII, p. 26, 1891.

¶Die parasitischen Exoascen. Ibid, x, 2, p. 49, 1893.

PRUNUS PENNSYLVANICA L. Wild Red Cherry.

Exoascus insittiae Sadeb.

I have referred to this species, specimens collected by Seymour at Temple, N. H., June 16, 1888, on the leaves of *Prunus pennsylvanica* L. It was distributed as *Taphrina deformans* (Berk.) Tul., in Seymour and Earle's Economic Fungi, No. 15. The specimen in the collection to which I have had access shows several small twigs curved to one side growing from the end of a larger twig. The specimen has very much the appearance of a small "witches broom." The young twigs are pale and slender, and the leaves are not much deformed, the upper surface being somewhat folded, while a large portion of the under surface is covered with the asci which give them a greyish white appearance. The mycelium is present in the inner tissue of the leaf but is not nearly so abundant as in the peach.

The asci are quite regularly smaller than those of *E. deformans* on the peach. Through the kindness of Mr. J. B. Ellis I have had the opportunity of seeing a specimen of this species on *P. domestica* from Sweden, and the asci are very much nearer those on that specimen than on the peach. In the measurements given by Sadebeck the asci are 25 long by 8-10 in diameter, which agrees quite well with the specimens on *P. pennsylvanica*, though on the latter some specimens measure 30 long, but the average is near 25. The stalk cells are 6-8 high by 7-9 in diameter and taper in many cases a little below, and then frequently intruding slightly between the cells of the epidermis. The measurements given for the stalk cells by Sadebeck are slightly larger, being 8 high by 8-10 in diameter. Aside from these slight variations it agrees very well with Sadebeck's species. It was first described by Sadebeck* from specimens on *Prunus insittia* and was later found by him on *Prunus domestica*. It forms "witches brooms" on both these trees in Europe.

* Unters. ü. d. Pilzgattung *Exoascus* etc. Abgedruck. a. d. Jahrb. d. Hamb. Wiss. Anst. p. 113, 1884.

Kritische Unters. ü. d. durch *Taphrina*-Arten etc. Ibid, VIII, p. 27, 1891.

Die parasiten *Exoascen*. Ibid, X, 2, p. 48, 1893.

PRUNUS DOMESTICA L. Plum.

Exoascus pruni Fuckel.

This fungus forms the well known "plum pockets," or "plum bladders" on the fruit *Prunus domestica*, the common cultivated plum. The mycelium is perennial in the fruit bearing branches and from these places grows out into the young ovaries in the spring. All or nearly all parts of the ovary are affected and the fungus stimulates the tissue of the ovary so that a remarkable hypertrophy occurs. The tissues become dry and spongy, the form of the plum being considerably enlarged. No stone is developed in the diseased plums and the interior is hollow and frequently traversed by loose threads of torn tissue. All of the plums on an affected tree are not usually affected, though I recollect seeing a tree in Chapel Hill, N. C., in the spring of 1886, on which there was not a single plum free from the disease. Frequently there are plums unaffected in the same cluster with the diseased ones.

The asci are very closely crowded together and frequently may develop quite irregularly, a few pushing through the cuticle first, followed later by others. A section of an affected fruit at this time would then show some asci very long and mature while others are not quite mature and the spores undifferentiated. There are many cells of the hymenium intermingled with the asci. The asci measure, in specimens which I have seen on *P. domestica* from Wisconsin, 30-60 long by 7-10 in diameter, and the stalk cells 15-22 high by 3-7 in diameter are rounded, or rarely pointed below. The longer asci are nearly cylindrical and many of the shorter ones slightly clavate. The spores are oval to elliptical, and from 3.5-5 in diameter. The measurements given by Sadebeck show a greater diameter, the ascus reaching a diameter as high as 15, and the stalk cell being given as 8 in diameter.

Robinson* speaks of a dimorphism in the asci, the slender ones being 43-60 long and 5.5-7 in diameter, while the stouter ones were 27-35 long by 9-12 in diameter. The size of the stalk cells he gives as 12-18 high by 5-8 in diameter. He also notes the fact that nearly all the asci which he examined were more slender

*Notes on the genus *Taphrina*. Ann. Bot. I, p. 166-7, 1887-8.

in proportion to their length than those described by Sadebeck. I have seen specimens probably of this species on *Prunus domestica* in North, and South Carolina, but unfortunately did not preserve any of them.

The shoots of *Prunus domestica* are sometimes deformed and enlarged bearing mature asci, the structure somewhat resembling that on the twigs of *Prunus angustifolia* Marshall. Prof. Halsted sent me some specimens collected at Manalapan, N. J. They are very old and overrun by some species of *Gloeosporium* so that it is not safe, it seems to me to attempt to decide what the species is. Some of the asci are illustrated in fig. 69.

PRUNUS SEROTINA Ehrhart. Black Wild Cherry.

Exoascus farlowii Sadebeck.

The ovaries of *Prunus serotina* are deformed by this species, the fruit becoming a spongy mass of tissue which is hollow within much as in the case of the fruit of *P. domestica* when affected by *E. pruni*. The ovaries are proportionately much more elongated, spindle shaped and curved, the end usually tapering to a long point. The floral envelopes are also hypertrophied and become persistent, which is not the case with *E. pruni* on the fruit of *P. domestica*.

The species was first described by Sadebeck* in 1890, from material collected by Dr. Farlow at Cambridge, Mass. In the material which Sadebeck examined he found the asci not crowded, but separated from each other, and this peculiarity, along with characters of the ascus and stalk cells, caused him to separate it from *E. pruni*, to which it had doubtfully been referred.† The distant asci, especially in the material examined by myself, does not seem to be a constant character, or even a frequent one, and I have examined quantities of material from Alabama, some from Canada, and some from Cambridge, collected by Dr. Farlow, and also by Halsted. The characters given by Sadebeck must then

* Kritische Unters. ü. d. durch Taphrina-Arten, etc. Ab. a. d. Jahrb. d. Hamb. Wiss. Anst. VIII, p. 30, 1891. See also Die parasiten Exoasceen, Ibid, X, 2, p. 47, 1893.

† Robinson, Notes on the genus Taphrina, Ann. Bot. I, p. 167, 1887-8 Ellis' N. A. F. No. 298. Here it is called *E. pruni*.

be modified so as to include the specimens with closely crowded asci. It is possible in specimens where the hymenium has not become evenly distributed over the surface that a section would show some asci which were considerably separated. But not taking this character into consideration I should consider it a distinct species from *E. pruni*. In 1889 I found a small quantity of this species in South Carolina, at Columbia. During the years 1890-93 I observed it as very common in Alabama, at Auburn. Quite large trees would have nearly all the fruit destroyed each year by it.

The asci are cylindrical and rounded or truncate at the free ends. They measure 20-33 long by 8-12 in diameter. The stalk cells are 12-20 high by 8-12 in diameter, averaging about one-third the length of the entire fruit body. These measurements give a greater diameter than that given by Sadebeck, 8-9 being the diameter given by him for the asci and stalk cells. The stalk cells frequently taper somewhat below and intrude themselves slightly between the cells of the epidermis at times. The mycelium I have not found to be so abundant in the tissues as is the case with *E. pruni* on *P. domestica*. The spores are more constantly rounded in form being approximately spherical, and are 3-4 in diameter. See figures 34-36.

Exoascus varius n. sp.

The leaves of *Prunus serotina* are frequently affected with a species of *Exoascus* which produces a folding or arching of the leaf. During the years 1890-3 I observed this to be very common and injurious on many trees in Alabama. In fact the same trees which were affected with the *E. farlowii* on the fruit had their leaves also badly affected. The shoots also were much deformed and sometimes enlarged, but there was not observed any tendency to the formation of "witches' brooms." Nor were any of the twigs observed to bear the asci. The deformity of the twigs or shoots occurred at the ends of the leafy branches, the leaves of the same being also diseased. Figures 13 and 14 are from photographs taken from living specimens. The deformity of the leaves and ends of the branches can be well seen. It is quite remarkable that the fruit of the same branches is also

affected, and this is well shown in the same illustrations. Large trees, thirty and forty feet in height, presented a very interesting sight and were noticeable for a considerable distance on account of the defective foliage, and especially from the brown and dead colors which succeeded the dying of badly affected leaves. The two forms, the one on the fruit and the one on the leaves, were so common on the same trees and so closely associated that many times I have been strongly inclined to consider them one and the same species. This inclination has been strengthened by a study of the structure of the fungus, for in many cases the asci and stalk cells on the leaves are very much like those of *E. farlowii* on the fruit, as can be seen by a reference to figures 26-31. In fig. 26 the asci measure 20-27 long by 8-10 in diameter and the stalk cells are 12-17 high by 8-10 in diameter. These are the largest ones which I have noted and they come very near to typical ones of *E. farlowii* on the fruit. In fig. 27 the asci and stalk cells possess the same proportionate lengths, but the entire fruit body is shorter, while the width is the same. Specimens occur, however, in which the proportion between the length of the ascus and stalk cells is different and the stalk cell may be only one-fourth as long as the entire fruit body instead of one-third, and the relation of the form to that of *E. deformans* becomes more apparent. But at the same time the stalk cell preserves quite constantly the same or nearly the same diameter as the ascus, and in a larger number of cases it is much longer than that of the latter species. Specimens on the leaves from Smyrna, Del., communicated by Mr. J. B. Ellis, present much the same characters, and some of the variations are illustrated in figs. 30, 31. Specimens on the leaves from Temple, N. H., collected by Mr. A. B. Seymour, also agree in these characters, as shown by some of the asci illustrated in fig. 32. The spores are rounded and four to eight in an ascus.

A form similar to this I collected at Columbia, S. C., in the spring of 1889. A few leaves of a shoot which grew from the base of a large tree were affected. Unfortunately these specimens are now lost. On the same tree, but not near the affected leaves were a few of the fruits affected by *E. farlowii*. I should still be strongly of the opinion that the fungus on the leaves of *P. serotina*

were but a leaf form of *E. farlowii* if it were not for the fact that I have observed two very different species of *Exoascus* growing in very close proximity to each other on the same tree, so close in fact that it is quite probable the mycelium of the two was intermingled in the branch which bore the affected fruits and leaves. These occur on *Prunus americana* under which paragraph the description of the species will be found. Another reason for considering them distinct species is the probable fact that usually a certain species quite constantly exercises a peculiar physiological influence upon the host, and that if the form on the leaves and twigs of *P. serotina* described here were the same species as that which occurs on the fruit of the same tree, we would expect it to produce a spongy abnormal growth in the buds and ends of the branches just as *Exoascus mirabilis* Atkinson does in the buds of *Prunus angustifolia*. For these reasons and from the fact that the fungus departs too widely from the characters of *Exoascus deformans*, it seems best to consider it as a distinct species, and I propose the name *E. varius* for it on account of the variable proportion which exists between the length of the ascus and stalk cell.

PRUNUS MARITIMA WANG. Beach Plum.

Exoascus communis Sadebeck.

This species affects the fruit of *P. maritima*, causing the plum "pockets." The specimens which I have seen were collected by Dr. Farlow at Dartmouth, Mass. Sadebeck* has recently described this species as occurring on this host as well as on *P. pumila* L. and *P. americana* Marshall, all from the United States. The structure of the asci and the relation of the stalk cells to the epidermis is represented in fig. 58. The asci are slender, rather slightly clavate, and rounded or somewhat truncate at the free ends. Sadebeck gives the measurements for the species as follows: The asci are 30-40 long and about 8 in diameter, the stalk cells 15 to 20 high by 3-5 in diameter. Although the stalk cells are often somewhat pointed below he says they do not intrude between the cells of the epidermis. The measurements I have taken from the asci on *P. maritima* vary but little from

*Die parasitischen Exoasceen. Ab. a. d. Jahrb. d. Hamb. Wiss. Anst. X, 2, p. 47, 1893.

these dimensions, the asci being 25-45 long by 6-8 in diameter, and the stalk cells 15-25 long by 3-6 in diameter. They are somewhat pointed below and according to my observations do, to a slight extent, project between the cells of the epidermis, but not markedly so. The spores are rounded or oval in form and are 3-4 in diameter.

PRUNUS NIGRA AITON. Wild Red Plum.

Exoascus communis Sadebeck.

Fruits of this plum distorted into the usual "pockets" or "bladders," collected by C. H. Davis, at Alma, Mich., June 2, 1894, were communicated to me by Prof. L. H. Bailey. The fungus agrees with Sadebeck's *E. communis*. The asci measure 35-45 long by 7-9 in diameter, and the stalk cells 15-22 high by 4-6 in diameter. The stalk cells are frequently pointed below and occasionally intrude slightly between the epidermal cells as in *E. communis* on *P. maritima*. The structure of the fungus and the relation of the stalk cells to the epidermis is represented in fig. 60.

PRUNUS PUMILA L. Dwarf cherry.

Exoascus communis Sadebeck.

Exoascus communis is also described by Sadebeck on the dwarf cherry, *Prunus pumila* L. Mature conditions of the fungus on this plum I have not seen. The plum "bladders" were formed on the fruit of this species on some plants which are growing in the Horticultural grounds of Cornell University, in June, 1894. A photograph showing the form of these "bladders" and the normal fruit is represented in fig. 19. The surface of the swollen fruits is quite uneven, and the tissue is characteristic of similar tissues in other species of plums thus affected. These specimens unfortunately did not mature their asci.

PRUNUS ANGUSTIFOLIA Marshall. Chickasaw plum.

Exoascus mirabilis n. sp.

This remarkable species deforms the leaf buds and young twigs of *Prunus angustifolia* Marshall, the Chickasaw plum (*P. chicasa* Michx.). It also occurs on related species of *Prunus*. I observed it in the vicinity of Columbia, S. C., in May, 1889, and

during three years, 1890-92, I observed it as very abundant at Auburn, Ala., both on the wild *P. angustifolia* and its cultivated varieties. It produces in the young leaf buds and the ends of the young twigs an enlarged structure, the tissue of which is very much like that of the plum "bladders." The swollen bud or twig is usually whitish or yellowish white in color, the tissue is soft and spongy, and the structure is hollow at the center. They vary greatly in form, being clavate, oval, lanceolate, or elliptical; while the surface varies also to an equal extent, depending upon the stage of development of the bud or twig at the time that the growth is arrested. The bud may be brought well under contribution before the leaves have begun to open, when the large mass of tissue will present no appearance of even the leaf tips. Sometimes the leaves partly separate and then short or long points which are of the same kind of tissue will project from the bulk of the mass. Again, the leaves may be more or less expanded, so that some of them present green normal tips projecting from the swollen bud, and from this the green expanded portion varies through different specimens so that in some there are normal leaves standing out from it. Two of these conditions are reproduced from photographs of fresh specimens in figures 10 and 11, Plate V.

The asci are developed all over the surface of the spongy portion of the structure, and give it a mealy appearance. The twig is sometimes enlarged and deformed to some distance below the enlarged spongy end, and it is not rare to find, especially at a rather late period for the development of the asci, twigs slightly enlarged for a considerable distance, but bearing no asci. The fungus in structure is rather closely related to *Exoascus pruni*, and at one time I considered it identical with that species. Specimens collected by myself in Alabama were distributed by Seymour and Earle* as *Taphrina deformans* (Berk.) Tul.

The asci are slightly clavate, rounded or truncate at the free ends, and measure 25-45 long by 8-10 in diameter. The stalk cells are 10-18 high by 5-8 in diameter, and are usually rounded or truncate at the base. They do not intrude between the cells of the epidermis. The spores are quite regularly elliptical, or rarely

* *Economic Fungi*, No. 129.

oval, agreeing in this respect somewhat with the spores of *Exoascus rostrupianus** Sadeb. but not so large as in that species.

The mycelium is very abundant in the tissues of the affected buds, forming a very complex network of threads between the cells of the hypertrophied tissue. The details of structure are shown in figures 61 and 62.

The same fungus also occurs in Iowa, specimens collected on *Prunus angustifolia* (*P. chicasa*) in Chickasaw Co., by Prof. L. H. Budd, were communicated to me by Prof. L. H. Pammel.

The mycelium is perennial in the branches, and in the following spring the young buds from such branches are more likely to suffer from attack.

Exoascus mirabilis var. *tortilis* n. var.

This form occurs on the fruit of *Prunus angustifolia*, very rarely producing the plum "bladders," and then the fruit is only affected on one side and is strongly curved. Usually the attack is confined to a rather small area or so small that a considerable portion of the fruit retains its normal form and color, and it is not hollow within. The structure of the fungus is but little different from that on the buds, the chief differences being in somewhat larger development, so that the asci are somewhat longer and the stalk cells higher. The other characters, including those of the mycelium are the same as in the form on the buds. The propriety of separating the form on the fruit as a variety may be questioned, but it seems well to do so in order to avoid possible confusion, since the form on the buds is the more common one in localities where I have observed it, and quite frequently trees may present many buds which are affected when all the fruits are free from attack.

Erwin Smith† notes the occurrence of both these forms on *P. angustifolia* and its cultivated varieties in Maryland and Georgia. He suggests that it may be distinct from the *E. pruni*.

Many of the native trees are very seriously affected, and it seems in some cases to be spreading and becoming serious in the plum orchards in the southern states.

* Die parasitischen Exoasceen. Ab. a. d. Jahrb. d. Hamb. Wiss. Anst. X, 1, p. 46, 1893.

† Jour. Mycology, p. 108, vol. VI.

PRUNUS HORTULANA L. H. Bailey.

Exoascus mirabilis. Atkinson.

The buds and ends of the branches of *P. hortulana* are affected exactly like those of *P. angustifolia*, and the fungus seems to be identical with the species on that plant. All of the specimens were communicated to me by Prof. Pammel. Some of the details of the asci, etc., are illustrated as follows. Fig. 70 from specimens collected at Ames, Iowa, in May, 1894; fig. 72 from specimens collected by Dr. A. B. Dennis at Cedar Rapids, Ia., May, 1894. These specimens which I examined were rather young and comparatively few of the asci were fully developed. Fig. 68 is from specimens collected by Mrs. R. M. Kellum, at Salem, Ia., June 8, 1894. In this specimen the asci and stalk cells were much longer than in any of the other specimens, though the relative proportions between the asci and stalk cells remain about the same. This specimen was marked "*Prunus chicasa*, 'Wild Goose Plum.'" Prof. Bailey has determined it as *P. hortulana*.

Figs 70 and 72 agree in all respects with the type.

Fig. 71 represents the asci and the relation of the fruit structures to the epidermal cells in specimens from the buds of *Prunus hortulana* var. *mineri*, also from Iowa, collected by A. Noe, in May, 1894. These also agree with the type on *P. angustifolia*.

PRUNUS AMERICANA Marshall. Wild Red Plum.

Exoascus longipes n. sp.

The specimens which constitute the type of this new species were collected at Danby, N. Y., by T. A. Mandeville. A photograph of the twig bearing numerous "bladders" and a normal fruit is reproduced in fig. 3, Plate II. The hypertrophied fruits are irregularly long ovate and sometimes slightly curved. The fungus is quite different from any of this class described hitherto on the fruits of *Pruni*. It is characterized chiefly by the very long stalk cells and from the circumstance that they intrude themselves prominently between the cells of the epidermis. The asci are slightly clavate and rounded or somewhat truncate at the free end. They are 30-40 long by 7-10 in diameter. The stalk cells are 25-35 high by 3-5 in diameter, being usually much narrower

below. The lower ends of the cells of the hymenium begin usually to intrude themselves between the cells of the epidermis at quite an early stage of development. Fig. 47 shows this relation of the cells of the hymenium to the epidermal cells. This results from a peculiarity of the development of the ascogenous cells from the first mycelium which spreads beneath the cuticle. The growth from these cells proceeds inward, that is, toward the epidermis, as well as outward in the direction of the formation of the ascus. This is quite markedly the case in all the long stalked species of *Exoascus* which I have examined, even of *E. pruni*, *E. communis*, *E. mirabilis*, and others. It is however much more marked in this species than in those just quoted, especially the long inward growth of the stalk cells. After many of the asci are quite well developed and are somewhat crowded, the hymenium continues to increase in a peculiar manner in all of these species but more so in some than in others. An ascogenous cell develops somewhat below the middle a slender branch which grows inward toward the epidermis. After having grown downward for some distance, sometimes having reached a length of 15-20, the outer end begins to grow outward to form the ascus. A series of these with a young ascus is shown in fig. 49. In this way the lower ends of the stalk cells will frequently be at a very irregular line, some of them not intruding between the cells of the epidermis while others are crowded far down between them. *Exoascus rostrupianus* probably develops the later hymenium in this way to judge from Sadebeck's description, and also from the fact that it is a long stalked species. But according to Sadebeck* the stalks do not intrude themselves in the least between the epidermal cells. The spores are also quite different, being quite constantly elliptical, and the conidial formation from budding of the spores in the ascus being very rare. The spores in *E. longipes* are round or oval, measuring 3-4 in diameter.

When the asci are developing from these later hymenial cells it frequently happens that the septum separating the stalk cell from the ascus is formed below the connection of the fruit body with its neighbor from which it had its origin.

* Die parasitischen Exoasceen. Ab. a. d. Jahrb. d. Hamb. Wiss. Anst. X, 2 p., 29, 1893.

The mycelium is very abundant in the tissues of the hypertrophied fruits, forming a well developed network of threads between the cells as in other species of this type.

These are the only specimens on *P. americana* Marshall of this species which I had the opportunity to examine. Other specimens of hypertrophied fruits of *P. americana* were collected near Ithaca, N. Y., during June, 1894, and judging from a photograph which I have seen of them the form of the hypertrophied fruit is quite different. The specimens have either been mislaid or lost so that at this time there is no means of examining them to see whether they belong to this species or to *E. communis* Sadebeck.

Exoascus communis Sadebeck.

Sadebeck* reports this species on *Prunus americana* Marshall from the United States, collected by Bartholomew. To it I have also referred specimens collected by Seymour at Madison, Wis., June 3, 1886, and distributed as *Taphrina pruni*† (Berk.) Tul.

Specimens on the fruits of cultivated varieties of *P. americana* communicated by Prof. Pammel, and collected in Iowa, show a much distorted fruit in many specimens, especially of the "Cheny" variety. In some of these fruits only one side appears to be affected, resembling in this respect very much, the fruits of *P. angustifolia* deformed by *E. mirabilis* var. *tortilis* Atkinson. The form of the stalk cells also seems to be nearer those of that species than of *E. communis*, and I do not feel like definitely locating the form until we know more about the relation of these hypertrophied fruits of the cultivated varieties of *P. americana* to the deformed buds which also occur on *P. americana*, and which appear to be identical with those on *P. angustifolia* and *P. hortulana*.

The asci of the "Cheny" and "Baldwin" varieties of the form on the fruit of *P. americana* are shown in detail in figures 40-43, 42 representing the asci of the Baldwin variety.

* Die parasitischen Exoasceen. Ab. a. d. Jahrb. d. Hamb. Wiss. Anst. X. 2, p. 47, 1893.

† Seymour and Earle, Economic Fungi, No. 13.

Exoascus mirabilis Atkinson.

To this species I refer the form on the buds of *P. americana* Marshall, from Iowa, specimens communicated by Prof. Pammel, and by Prof. Seymour. The asci, stalk cells and spores are shown in figs. 68 and 69.

Specimens of probably this same species on the buds of the Maquoketa* plum were reported from Iowa in 1888, the Maquoketa being here inadvertently referred to the Chickasaw plum.

Exoascus decipiens n. sp.

This species distorts the leaves and young shoots of *Prunus americana* Marshall. Specimens have been collected at Danby, N. Y., by T. A. Mandeville, and at Aetna, N. Y., by the writer. A photograph of two of the specimens from Danby are reproduced in figs. 5 and 6, Plate III. The young shoot is somewhat enlarged, though there are developed no asci on any of the shoots which I have seen. In fig. 5 some of the leaves can be seen to be finely wrinkled near the base. The affected part of the leaf is usually thrown into a series of very fine folds or wrinkles, and the under surface, which at the time of the maturity of the asci is frequently farther injured, presenting a scurvy appearance, is covered by scattered groups of rather loosely associated asci. No asci have as yet been found upon the upper surface, and from careful examination I have not been able to detect any development corresponding to the "witches brooms," so that the species seems to be well differentiated from *E. insititiae* Sadeb. The asci are also much larger and different in other respects than those of that species. They are nearly cylindrical and rounded or rarely truncate at the free ends, and measure 20-40 long by 7-10 in diameter. The stalk cells are quite broad, frequently broader than the asci, and measure 6-13 high by 7-12 in diameter. They are usually rounded below, but sometimes are pointed much as in *E. deformans* on the peach. The spores are oval or broadly elliptical, measuring 3-4 in diameter. Quite frequently conidia are developed by budding while still within the ascus.

* Report Dept. Agr. p. 363, 1888.

Where the leaves are fully expanded or nearly so before they are seriously attacked the injury is confined chiefly to the base of the leaf and the petiole. Sometimes isolated spots nearer the tip of the leaf are also affected. If the leaves are seriously attacked when quite young they become killed, still clinging to the branch and with no development of asci dry, become crisp, and black. The blades of leaves only partially affected also become black, the lamina first and the petiole later, especially when the serious attack is chiefly confined to the base of the leaf. This dying of the affected parts often continues into the shoot, which presents also a blackened appearance. One of these shoots with blackened leaves in different stages of development is reproduced from a photograph in fig. 17, Plate VIII.

The mycelium is perennial in the young branches, and occurs in the intercellular spaces of the affected parts.

See figures 74-77, Plate XIX, for details.

Fig. 5, Plate III, shows also the fruits of *P. americana* deformed by *Exoascus longipes* Atkinson, growing from the same shoot as *Exoascus decipiens* and very near it. In the shoot the mycelium of the two species is probably somewhat intermingled, but there can be no doubt about the two being different species, for they represent very remote types of *Exoascus*.

Exoascus decipiens var. *superficialis* n. var.

On half formed fruits of *Prunus americana* Marshall, at Aetna, N. Y., I have found an *Exoascus* which may prove to be a distinct species. I have not had as yet sufficient material to give it the careful study to determine this point. I therefore prefer at the present to place it as a variety of *E. decipiens* Atkinson, especially as it occurs in the cases thus far observed on the same tree on which I collected *E. decipiens* at Aetna, N. Y. The first specimens were collected July 6, 1894. At this time the *E. decipiens* on the leaves had nearly disappeared, at least the fruiting condition of it. The fungus on the fruit at this time was not mature, but was collected in a mature condition on July 28. The fruits as stated above are half formed and the stone is normal, or at least not wanting. For this reason I have proposed the name *superfi-*

cialis. On the affected parts the mycelium penetrates to some depth, however, in the tissue and warty swellings appear, or a large part of the surface is laid under contribution to the fungus. Two of these hypertrophied fruits showing the extremes of this condition are reproduced in fig. 7, Plate III.

On the specimens which were collected July 28, the surface of these warty projections was roughened and finely cracked, and beside the mature asci which were present there were other fungi of a saprophytic nature, especially a specimen of *Cladosporium*, though not in profusion. The hymenium was upon the surface of this tissue. The asci are about 25-30 long by 8-11 in diameter, and some of them presented a constriction near the base. The stalk cell in the specimens seen were very short, but farther study is necessary to determine these characters. The asci, however, are near the type of those on the leaves. Whether the mycelium is perennial in the branches and grows out into the fruits, or whether infection takes place by spores from the species on the leaves cannot at this time be stated. If the former were the case there would seem good ground for considering it as a distinct species.

PRUNUS TRIFLORA Roxburgh. Japan Plum.

Exoascus rhizipes n. sp.

This very interesting species was collected by the writer on Japan plums of the variety sometimes called Botan, or Botankio. It was collected at Auburn, Ala., May 1, 1892. Superficially the hypertrophied fruit and buds resemble those on the Chickasaw plum (*P. angustifolia*). One specimen, in which an affected fruit and bud were growing very close together on the same branch, was photographed and is reproduced in fig. 4, Plate II.

While the superficial resemblance is close to the hypertrophies caused by *E. mirabilis* Atkinson, the structure of the fungus is very different, and also differs markedly from any described species. It is more closely related to *E. longipes* Atkinson, but differs from that in the stalk cells which intrude much farther between the cells of the epidermis and by the frequent development of numerous rhizoids which are intermingled with the stalk cells and also penetrate between the epidermal cells. The lower part of

the slender stalk cell is frequently septate as are also the rhizoids. The stalk cells of *E. longipes* occasionally possess a few rhizoids, and this is the case in many of the long stalked species, but the occurrence on those species is rare. These rhizoids are developed both from the stalk cells and from the lower part of the ascus. Their origin is related, or similar in kind, to that of the development of the later portions of the hymenium in this and other species noted under the discussion of *E. longipes*.

A very thin section presents the appearance as if there were no stalk cells whatever, but that the asci arose from a very complex cellular hymenium of several layers in thickness, the inner layers of which are between the epidermal cells of the host.

The typical form is on the fruit and the structure of the asci and the relation of the stalk cells is shown in Plate XV, figs. 53-57. Some young developing asci from the fruit are shown in fig. 57, with a few rhizoids and young hymenial cells. The older asci are difficult to tease out well from their attachment in the epidermal cells so as to preserve all the rhizoids in situ. The asci are slightly clavate, are 30-40 long by 8-10 in diameter. The stalk cells reach a length of 25-35 or 40, and are 3-5 in diameter. The rhizoids and stalk cells as well are frequently septate. This occurs sometimes also in *E. longipes* but rarely compared with the occurrence in this species.

The young cells of the hymenium also more early intrude themselves between the cells of the epidermis. The intercellular mycelium is abundant as in the other related species. The spores are elliptical.

The form on the buds is similar, but the development of the rhizoids is not so profuse, nor are they so long. This may be accounted for I think from the fact that the fruit forms a more suitable nourishment and all the structures are forced to a greater development. The same relation exists between the form on the fruit in *E. mirabilis* and that on the buds, but in each case it is quite easy to properly correlate the two forms. On the bud the stalk cells intrude themselves far between the cells of the epidermis, as shown in fig. 53. In fig. 55 are shown three asci with their stalk cells and the connection near the septum dividing the stalk from the ascus.

PRUNUS VIRGINIANA L. Choke Cherry.

Exoascus confusus n. sp.

The fungus causing the hypertrophied fruits of *Prunus virginiana* have been referred, it seems to me improperly, to *Exoascus pruni*. Sadebeck* considers it identical with the *Exoascus* causing the hypertrophied fruits of *P. domestica* and places it in *E. pruni*. The asci are quite different and especially the stalk cells and their proportion to the asci. Figures 37-39, Plate XII, represent the details of these structures. Fig. 37 is from a rather young specimen from Forest Home, N. Y., and figs. 38, 39, from specimens collected by Underwood at Taburg, N. Y., communicated by Seymour. Comparing these figures with those of *E. pruni* from *P. domestica*, shown in figs. 44, 45, a great difference is seen. All of these illustrations of the structure of the asci, etc., are carefully drawn with the aid of the camera lucida to the same scale, so the comparison can well be made from the illustrations. The asci of this species on the fruit of *P. virginiana* are, according to these specimens, 30-45 long by 8-12 in diameter. The stalk cells are 15-30 high by 6-10 in diameter. The stalk cells are nearly or quite the same diameter as the asci and are proportionally longer than those of *E. pruni* on *P. domestica*, and Sadebeck† says upon examination that the fungus upon the fruit of *P. domestica* in the United States is the same as that in Europe upon the same host. The stalk cells also on the fruit of *P. domestica* are also more slender in proportion to the diameter of the ascus than in those on the fruit of *P. virginiana*.

The physiological effect upon the host is also quite different. Not only is the hypertrophied fruit much longer in proportion to the diameter than is the case with the fruit of *P. domestica*, but the floral envelopes are also constantly hypertrophied and become persistent, which is not the case with the same organs of the flower of *P. domestica*. The asci are also developed on the floral organs.

* Kritische Unters, etc. Ab. a. d. Jahrb. d. Hamb. Wiss. Anst. VIII, 29, 1891.

† Die parasitischen Exoasceen. Ibid. X, 2, p. 44, 1893.

Robinson* calls attention to the fact that the asci on the fruit of *P. domestica* are much more slender than the measurements given by Sadebeck would indicate. In a later contribution Sadebeck† himself indirectly gives some ground for considering this a distinct species from the *E. pruni* on *P. domestica*. In this communication he thinks it possible that a careful examination of the fungus on the fruit of *Prunus padus*, which he previously studied and placed in *E. pruni*,‡ may prove to be a distinct species. The hypertrophied fruits of *P. padus* agree in external appearance more nearly with those of *P. virginiana* than with those of *P. domestica*, and the floral organs of *P. padus* are also hypertrophied. *Prunus padus* and *P. virginiana* both belong to the same type of the genus *Prunus* and to a different type from that to which *P. domestica* belongs.

I should consider the fungus on *P. virginiana* much more nearly related to the *E. farlowii* on *P. serotina* than to *E. pruni*.

The relative size of the asci and stalk cells as well as the proportionate length of the same, suggest this, as can be seen by comparing the illustrations of the two. Figs. 34-36 being those of *E. farlowii* and 37-39 being those of the species on the fruit of *P. virginiana*. There are, it seems to me, however, good specific differences between these two, the base of the stalk cells in *E. farlowii* being frequently narrower and running to a point which intrudes somewhat between the cells of the epidermis. The asci of *E. farlowii* are also much shorter, and the stalk cells are proportionately a little broader. I therefore propose for the fungus on the fruit of *P. virginiana*, the name, *Exoascus confusus*.

Exoascus cecidomophilus n. sp.

This is a very interesting species which I have found upon the fruits of *Prunus virginiana* which were deformed by a species of *Cecidomyia*. The species was discovered too late in the season to say whether the larvæ attacked the fruit before or after the attack by the fungus. I believe at this time, however, that the cecidomid larvæ attack and deform fruits which are not affected by the

* Notes on the genus *Paphrina*. Ann. Bot. I, p. 168, 1887-8.

† Die parasitischen Exoasceen. Ab. a. d. Jahrb. etc. X, 2, p. 45, 1893.

‡ Kritische Untera. etc. Ibid. VIII, p. 29, 1891.

fungus. Certainly the larvæ control to the greater extent the form of the gall, which is very different from that produced by any hitherto known species of the *Exoasceae*. Neither the floral envelopes nor the stamens suffer hypertrophy, the carpel alone being concerned. This is transformed into a peculiar hollow and open gall, the opening being at the base of the ovary and appearing as if it were formed by the cracking away of a portion of the base from the receptacle, as the base of the fruit by hypertrophy increases in size. The peculiar shape of the gall is shown in figs. 15 and 16, Plate VII, reproduced from a photograph. They are from 1.5–2.5 cm. long and somewhat less than 1 cm. in diameter, being two to three times longer than broad. They are somewhat broader than the normal fruit and two to four times longer, as can be seen in the illustration in which are shown a few normal fruits attached to the same cluster. Sometimes only one or two of the fruits in a raceme are affected. This trouble seems to be a very common one in the vicinity of Ithaca, N. Y. It is especially abundant along the Dryden road between Aetna and Varna, where it was first noted by Prof. J. H. Comstock. The gall is nearly oblong in outline, with rounded ends, a slight inflation at the middle and a constriction near the base, so that the very base seems to flame outward as if inverting. It is also more or less curved.

The fungus does not occupy the entire gall and does not penetrate to a very great depth in the tissues, while the mycelium is rather scanty. Sections, however, do show that the mycelium penetrates in the subepidermal tissue to some extent between the cells over a portion of the gall. The side of the gall which is affected by the fungus is more strongly arched than the unaffected side. Whether the slight curve which has thus far been observed to be present to some extent in all the galls examined, is caused by the presence of the mycelium, has not yet been determined. Several have been examined and the mycelium not found, but farther study is necessary to determine this point, and also to determine the exact relation of the cecidomid to it.

Before the galls die if they are cut open, several of the reddish larvæ of the cecidomid will be found inside clustered at the apex of the hollow interior. The cavity is quite large and smooth, and of a dark color.

The tissue of the gall is quite hard, especially so as compared with that of the ordinary "bladders" formed by species of *Exoascus*, and this taken with the scanty mycelium of the fungus and the peculiar shape of the gall is pretty strong evidence that the form of the gall is more strongly influenced by the cecidomid than by the fungus.

The fungus is very different from those which are known to produce the "bladders" or "pockets" of the fruits of *Prunus*. The asci are cylindrical or slightly clavate and rounded at the free ends. They are 30-40 long by 6-10 in diameter. The stalk cells are very broad, being 6-10 high by 10-15 in diameter. They are usually rounded and blunt below and do not at all intrude between the cells of the epidermis. The asci are scattered or rather loosely aggregated. Figs. 73, 78, 79, illustrate the asci, etc., of this species. The spores are rounded or elliptical, and very frequently the formation of conidia by budding in the ascus takes place. In a few cases I have observed the spores in process of formation before the wall separating the ascus from the stalk cell was formed. Two such cases are represented in fig. 73. One case was observed where no wall was formed even when the ascus was mature and the spores occupied the entire fruit body. A few variations of this kind have been observed in some of the other species. Sadebeck records a case of the beginning of spore formation before the separating wall was developed.

Occasionally on the same trees which bear the cecidomid galls with the *Exoascus cecidomophilus* Atkinson, are the old mummified hypertrophied fruits caused by *Exoascus confusus* Atkinson (*E. pruni* of Authors). Fig. 16, Plate VII, shows a very interesting condition of the fruit which is sometimes seen. A single raceme bears several normal fruits, one mummified fruit the result of the attack of *E. confusus* in May or early June, and several fruits attacked both by a cecidomid and by *E. cecidomophilus* in July.

Exoascus sp

A species of *Exoascus* has been found deforming the leaves and twigs of *Prunus virginiana*, but thus far I have not seen the mature condition though several diligent searches have been made for it. To what species it belongs or whether the one in the

shoots is the same as the one in the leaves is not known. A few shoots on one tree by the roadside near Crowbar Point on the west shore of Cayuga Lake were found by me on June 28, 1894. They were enlarged for some distance from the ends and the greater diameter of the hypertrophied shoot was some distance from the end. They were also curved to one side by torsion, usually nearly at a right angle, but in one case the torsion had continued until the shoot made an entire revolution and the end then pointed in nearly the same direction as the main part of the shoot. This one is reproduced in fig. 18, Plate VIII. Some of the leaves of these same shoots were deformed by a species of *Exoascus*. Somewhat similar distortions of the leaves were found along the Dryden road between Aetna and Varna, July 6 and 28. A few only were found on a very few of the shrubs which also possessed the cecidomid galls. None of the shoots here were deformed. An examination of the tissues of the shoots and leaves thus deformed showed the presence of the mycelium of an *Exoascus*.

Fig. 84 represents the intercellular mycelium in a twig, and fig. 80 the mycelium and very early stage of the formation of the hymenium in a petiole of a very young leaf in a bud of the same.

PRUNUS DEMISSA Walp.

Exoascus varius? Atkinson.

Among other specimens communicated to me by Prof. Pammel was one from the Herb. of Prof. Wm. Trelease, collected in Ute Pass, Colorado, on the leaves of *Prunus demissa* Walp. The affected spots appear to have been arched and slightly folded, forming rather shallow open pockets, much like those which I have here observed on the leaves of *Prunus virginiana*, to which *P. demissa* is closely related. In the specimens observed the asci were developed on the upper surface of the leaves forming a whitish coating to the spots. Some of the asci are illustrated in fig. 33. Without more material and fuller observations I do not care to definitely locate the species. It is marked *Taphrina deformans*. It seems to me that the proportion existing between the length of the stalk cells and the asci is different from that in the specimens on the peach, and agrees more closely in that respect

with the fungus on the leaves of *P. serotina* L. which I have referred to *E. varius* n. sp. I would therefore provisionally refer it to that species.

CONCLUSIONS.

It is to be regretted that definite and conclusive experiments have not yet been made concerning the treatment and control of the diseases caused by the various species of the *Exoascea*, so that this information, which is most desired by fruit growers could be here confidently placed before them. It is hoped, however, that this contribution will give those interested a greater familiarity with the characteristics of the deformed leaves, fruits, and branches caused by this group of parasitic fungi and that this will lead to a more intelligent line of experimentation.

It should be remembered that the species possess a perennial mycelium which lives in the buds or branches of the trees, during the winter months, of plants which once have become infected. That a tree once affected is likely to show the disease more or less every year. Climatic conditions probably influence a greater or less injury from year to year, so that in some years little of the trouble may be observed when in other years it is more common. This has led some to suppose that the fungi are not perennial, but that a fresh infection each year is caused by the spores only. This is a mistake. There is abundant evidence from the results of several investigators to show that the mycelium is perennial, for it has been found during the winter months, and in the spring has been traced as it grows from the buds or branches into the young leaves or fruits. It is quite possible that one source of the original infection of trees is from the attacks of spores. I have several times attempted to inoculate healthy peach trees, or unaffected ones, from the spores taken from freshly mature specimens on affected trees. This I attempted at Auburn, Ala. Not only were spores sown on the young leaves and buds, but pieces of the leaves containing mature spores, and others containing the mycelium only were inserted into a slit in young buds and in the young branches near buds. In no case did any sign of the disease appear even after three years. Several of these incisions

were wrapped with moist cloth and kept moist for several days, while in other cases a moist chamber was made around the twig by covering it with quite a large test tube. Had young buds been inserted in the manner of budding during the month of August in all likelihood the disease would have appeared in a year or two. I know of no successful experiments made in inoculating peach or plum trees from the spores, although such results may have been attained. It is usually considered by most students of this group that it is rather difficult to secure results from the inoculation by spores in many of the species of *Exoascus* while in others it is comparatively easy. Sadebeck* succeeded in inoculating *Alnus incana* with the spores of *Exoascus epiphyllus*, and producing the characteristic disease. He says it is easier to produce an infection with this species than with any other of the species of *Exoascus* known to him.

Since the mycelium is perennial in the buds or young branches of affected trees no buds should be taken from such trees for budding nursery stock or budding in the orchard. Since nearly all of the affected leaves of the peach trees fall away before the time for the selection of buds, the trees should be carefully selected in the months of May and June in order to avoid those which have the disease.

Where only a few branches of a tree are affected, pruning a considerable distance below the affected portion might be tried, especially in the case of those plum trees affected with *E. mirabilis*, that is those having the bud deformations.

It may be well in concluding to give a list of the species of *Exoascus* described here as occurring on species of *Prunus* in the United States, with their host.

Exoascus deformans (Berk.) Fuckel, deforming the leaves and rarely the shoots of *Prunus persica* L.

Exoascus pruni Fuckel, deforming the fruit, causing "bladders" or plum "pockets" of *Prunus domestica* L.

Exoascus insititiae Sadebeck, causing "witches brooms" and deforming the leaves of *Prunus pennsylvanica* L.

Exoascus cerasi (Fuckel) Sadebeck, causing "witches brooms" and deforming the leaves of the same on *Prunus avium*.

* Kritische Unters., etc., 1891.

Exoascus confusus Atkinson, deforming the fruit and floral envelopes of *Prunus virginiana* L.

Exoascus farlowii Sadebeck, deforming the fruit and floral envelopes of *Prunus serotina* L.

Exoascus communis Sadebeck, deforming the fruits of *Prunus maritima* Wang., *P. pumila* L., *P. americana* Marshall, *P. nigra* Aiton.

Exoascus longipes Atkinson, deforming the fruit of *Prunus americana* Marshall.

Exoascus mirabilis Atkinson, deforming the leaf buds and twigs, forming "pockets," of *Prunus angustifolia* Marshall, *P. hortulana* L. H. Bailey, *P. americana* Marshall.

Exoascus mirabilis Atkinson var. *tortilis* Atkinson, distorting the fruit of *Prunus angustifolia* Marshall.

Exoascus rhizipes Atkinson, deforming the fruit and leaf buds of *Prunus triflora* Roxburgh.

Exoascus decipiens Atkinson, deforming the leaves and shoots of *Prunus americana* Marshall.

Exoascus decipiens Atkinson var. *superficialis* Atkinson deforming the surface of the fruit of *Prunus americana* Marshall.

Exoascus varius deforming the leaves and shoots of *Prunus serotina* L. and ? *P. demissa* Wang.

Exoascus cecidomophilus Atkinson, affecting cecidomid galls on the fruit of *Prunus virginiana* L.

GEO. F. ATKINSON.

NOTE. I wish to acknowledge my great indebtedness to the following persons who have aided me chiefly by the communication of material: Prof. L. H. Pammel, Prof. A. B. Seymour, Prof. T. Meehan, Prof. B. D. Halstead, Mr. J. B. Ellis and Mrs. Flora W. Patterson.

EXPLANATION OF THE PLATES.

All the illustrations in Plates X-XIX inclusive were drawn with the aid of the camera lucida to the same scale. One millimeter of the eye piece micrometer scale of this combination is drawn in each plate. The figures are magnified 30 times more than this scale.

Plate I. *Exoascus deformans* (Berk.) Fuckel, on leaves of *Prunus persica* (L.), peach. Fig. 1 from Ithaca, N. Y. The petioles and a portion of the stem are here also affected. Fig. 2 from Auburn, Ala.

Plate II. Fig. 3, *Exoascus longipes* Atkinson, in fruits of *Prunus americana* Marshall. One young plum at the right is sound and serves for comparison with the hypertrophied fruits. From N. Y.

Fig. 4, *Exoascus rhizipes* Atkinson, on fruit and bud of *Prunus triflora* Roxburgh, Japan plum. From Auburn, Ala.

Plate III. Figs. 5 and 6 *Exoascus decipiens* Atkinson in the leaves of *Prunus americana* Marshall. In 6 the shoot is deformed. In 5 the fruits are deformed by *E. longipes* Atkinson. From N. Y.

Fig. 7, *Exoascus decipiens* var. *cecidomophilus* Atkinson in half grown fruits of *Prunus americana* Marshall. The plum at the left shows but a few warty excrescences, while the one at the right is affected over a large part of the surface. From Aetna, N. Y., on the same tree on which *E. decipiens* was collected. Fig. 17 in Plate VIII is *E. decipiens* Atkinson from the same tree, on which the plums in fig. 7 were collected.

Plate IV. *Exoascus mirabilis* Atkinson var. *tortilis* Atkinson, in fruits of *Prunus angustifolia* Marshall (*P. chicasa* Michx.). Only one side of the fruit is attacked. In each figure one healthy and one affected fruit is shown. From Auburn, Ala.

Plate V. *Exoascus mirabilis* Atkinson in buds of *Prunus angustifolia* Marshall. In figure 10 several of the leaves were fully expanded before the bud was severely attacked. Fig. 12 *Exoascus mirabilis* var. *tortilis* Atkinson on fruits of *P. angustifolia* Marshall. All from Auburn, Ala.

Plate VI. *Exoascus farlowii* Sadebeck, in carpels of *Prunus serotina* L. Some of the carpels are not attacked and the flowers form a means of comparison with the affected ones. From Auburn, Ala.

Exoascus varius Atkinson, in the leaves and shoots of the same branches. The shoots are deformed and enlarged at the ends but are not developing "witches' brooms."

Plate VII. *Exoascus cecidomophilus* Atkinson, in fruits of *Prunus virginiana* L. deformed by cecidomid larvæ. In fig. 16 the strongly arched sides of the galls are the places where the *Exoascus* is located. Midway of the raceme is a mumified fruit which was deformed by *Exoascus confusus* Atkinson, earlier in the season. In each raceme are healthy fruits. From near Aetna, N. Y.

Plate VIII. Fig. 17, *Exoascus decipiens* Atkinson, blackening the leaves and shoot of *Prunus americana* Marshall. From Aetna, N. Y.

Fig. 18, *Exoascus* sp. deforming the shoot and leaves of *Prunus virginiana* L. From near Crowbar Point, west shore Cayuga Lake, N. Y.

Plate IX. *Exoascus communis* Sadebeck. Deforming the fruits of *Prunus pumila* L. From Horticultural grounds, Cornell University.

Plate X. Figs. 20-22. *Exoascus deformans* (Berk.) Fuckel. *a.* ascus, *st.* stalk cell, *hy.* cells of the hymenium, *ep.* epidermis, *m.* mycelium. Fig. 20 from LaFayette, N. Y., fig. 21, from Temple, N. H. Some of these asci have but four spores. Fig. 22 from Ames, Iowa.

Figs. 23, 24, *Exoascus insititiæ* Sadebeck, on leaves of *Prunus pennsylvanica* L., from Temple, N. H.

Fig. 25, *Exoascus cerasi* (Fuckel.) Sadebeck, from leaves of *Prunus avium* L., Germantown, Penn.

Plate XI. Figs. 26-32, *Exoascus varius* Atkinson on leaves of *Prunus serotina* L. Figs. 26-29 from Auburn, Ala., 30-31 from Smyrna, Del., 32 from Temple, N. H. Fig. 33 *E. varius?* from leaves of *Prunus demissa* Walp., Ute Pass, Colorado.

Plate XII. Figs. 34-36, *Exoascus farlowii* Sadebeck, on fruits of *Prunus serotina* L. Figs. 34-36 from Auburn, Ala., 35 from London, Canada.

Figs. 37-39, *Exoascus confusus* Atkinson, on fruits of *Prunus virginiana* L. 37 from Forest Home, N. Y., 38, 39, from Taburg, N. Y.

Plate XIII. Figs. 40-43, *Exoascus communis* Sadebeck? or *E. mirabilis* var. *tortilis* Atkinson? From deformed fruits of *Prunus americana*, cultivated varieties; 40, 41, 43, Cheny variety, 42, Baldwin variety. From Iowa.

Figs. 44, 45, *Exoascus pruni* Fuckel on fruit of *Prunus domestica* L., from Wisconsin.

Plate XIV. *Exoascus longipes* Atkinson, on fruit of *Prunus americana* Marshall. Fig. 46, section showing young hymenium etc., *c.*, cuticle, *h.*, hymenium, *ep.*, epidermis, *m.*, mycelium. 47, older hymenium showing the lower ends of the cells making their way in between the cells of the epidermis. 48, 50, 51, mature asci showing the stalk cells penetrating between the cells of the epidermis. 49, showing the successive development of the later hymenium and ascogenous cells. 52, a portion of the fruit where the subcuticular mycelium was not well distributed. From Danby, N. Y.

Plate XV. *Exoascus rhizipes* Atkinson, on fruit and bud of *Prunus triflora* Roxburgh. 53 and 55 from bud, 54, 56, 57, from fruit. Fig. 54 shows the young hymenium with the lower ends of the cells growing down between the cells of the epidermis. In the mature asci specimens are seen the rhizoids growing from the stalk cells. 57 represents some of these growing from the lower part of the ascus. Older fruit bodies have a much greater number of rhizoids. From Auburn, Ala.

Plate XVI. *Exoascus communis* Sadebeck. Figs. 58 and 59 from fruit of *Prunus maritima* Wang., Dartmouth, Mass. 60, from fruit of *Prunus nigra* Aiton, Alma, Mich.

Plate XVII. Figs. 61, 62, 63, 66, 67, *Exoascus mirabilis* Atkinson. 61 and 62 (type) from bud of *Prunus angustifolia* Marshall, Auburn, Ala., 63 from same in Iowa, 66 and 67 from buds of *Prunus americana*, Iowa.

Figs. 64 and 65, *Exoascus mirabilis* var. *tortilis* Atkinson, on fruit of *Prunus angustifolia* Marshall, from Auburn, Ala.

Plate XVIII. 70 and 72, *Exoascus mirabilis* Atkinson on buds of *Prunus hortulana*, L. H. Bailey, from Iowa, 71 same on P.

hortulana var. *mineri*., from Iowa. Fig. 68, highly developed specimens on bud of *P. hortulana*, Iowa. Fig. 69 from bud of *Prunus domestica*, N. J.

Fig. 73, *Exoascus cecidomophilus* Atkinson, on fruits of *Prunus virginiana* L. deformed by cecidomid larvæ. From Aetna, and other places in the vicinity of Ithaca, N. Y.

Plate XIX. Figs. 74-77, *Exoascus decipiens* Atkinson, on leaves of *Prunus americana* Marshall, from Danby, N. Y.

Figs. 78 and 79 *Exoascus cecidomophilus* Atkinson from fruits of *Prunus virginiana* L. deformed by cecidomid larvæ. In the vicinity of Ithaca, N. Y.

Plate XX. 81, 82 and 83 *Exoascus mirabilis* Atkinson from *Prunus angustifolia* Marshall, Auburn, Ala. 81 young hymenium and intercellular mycelium, 82 mature asci showing the connection of a portion of the hymenium with the mycelium, 83 superficial view of a portion of the hymenium. These figures are drawn to a different scale from 84 and 80 and this entire Plate is reduced more than Plates X-XIX.

Fig. 80 is from a petiole of a deformed bud and 84 from a deformed shoot of *Prunus virginiana* L. on which the fungus was not mature. In 80 is shown the intercellular mycelium and the very beginning of the hymenium underneath the cuticle. In 84 is shown a portion of the intercellular mycelium, after treatment with chloral hydrate.



PLATE I.—*Prunus persica* (L.), Peach. (*Exoascus deformans* (B.) Fuckel.)



PLATE II.—Fig. 3.—*Prunus americana* Marshall, wild red plum (*Exoascus longipes* Atkinson). Fig. 4, *Prunus triflora* Roxburgh, Japan plum (*Exoascus rhizipes* Atkinson).



PLATE III.—*Prunus americana* Marshall, wild red plum (fig. 5 *Exoascus longipes* Atkinson, in ovaries; *E. decipiens* Atkinson in leaves, fig. 6, *E. decipiens* Atkinson in shoot. Fig. 7, *E. decipiens* Atkinson var. *superficialis* Atkinson, in surface of half grown plums).



PLATE IV.—*Prunus angustifolia* Marshall, Chickasaw plum (*Exoascus mirabilis* Atkinson var. *tortilis* Atkinson in plums).



PLATE V.—*Prunus angustifolia* Marshall, Chickasaw plum (figs. 10 and 11, *Exoascus mirabilis* Atkinson in buds; fig. 12, *Exoascus mirabilis* var. *tortilis* Atkinson in plums).



PLATE VI.—*Prunus serotina* L., wild black cherry (*Exoascus farlowii* Sadebeck in carpels, *Exoascus varius* Atkinson in leaves and shoots).



PLATE VII.—*Prunus virginiana* L., choke cherry (*Exoascus cecidomophilus* Atkinson in fruits deformed by cecidomid larvæ.



PLATE VIII.—Fig. 17, *Prunus americana* Marshall, wild red plum (*Exoascus decipiens* Atkinson blackening the leaves and shoot). Fig. 18, *Prunus virginiana* L., choke cherry (*Exoascus* sp. deforming the leaves and shoot.)



PLATE IX.—*Prunus pumila* L., dwarf cherry
(*Exoascus communis* Sadebeck).

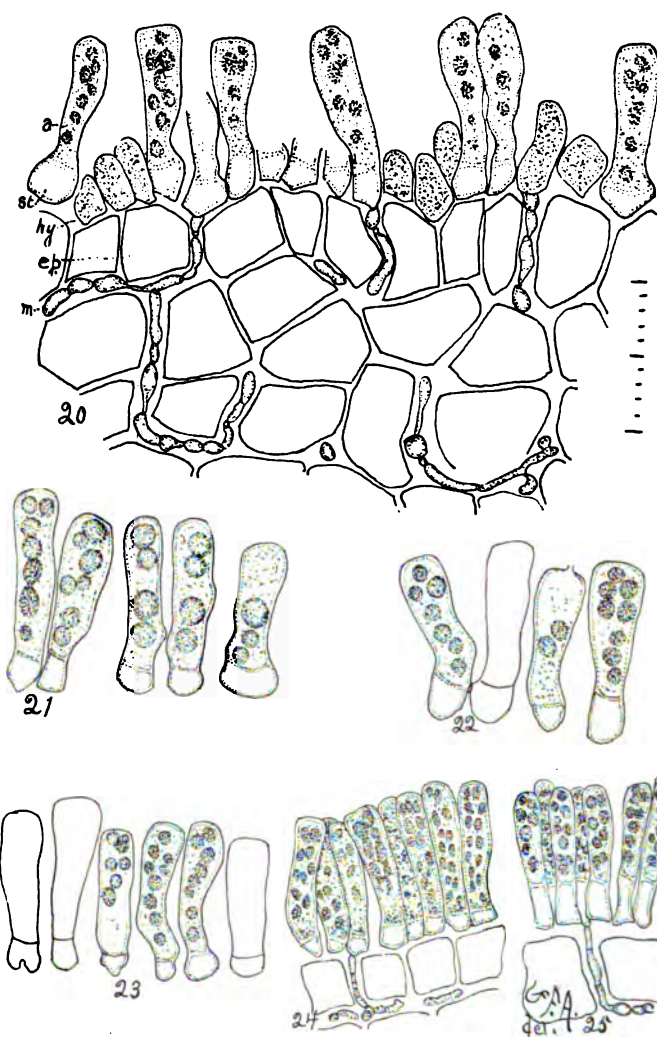


PLATE X.—Figs. 20-22, *Exoascus deformans* (Berk.) Fuckel, (on *P. persica* L.). Figs. 23, 24, *Exoascus insititiae* Sadebeck (on *P. pennsylvanica* L.). Fig. 25, *Exoascus cerasi* (Fuckel) Sadebeck, (on *P. avium* L.).

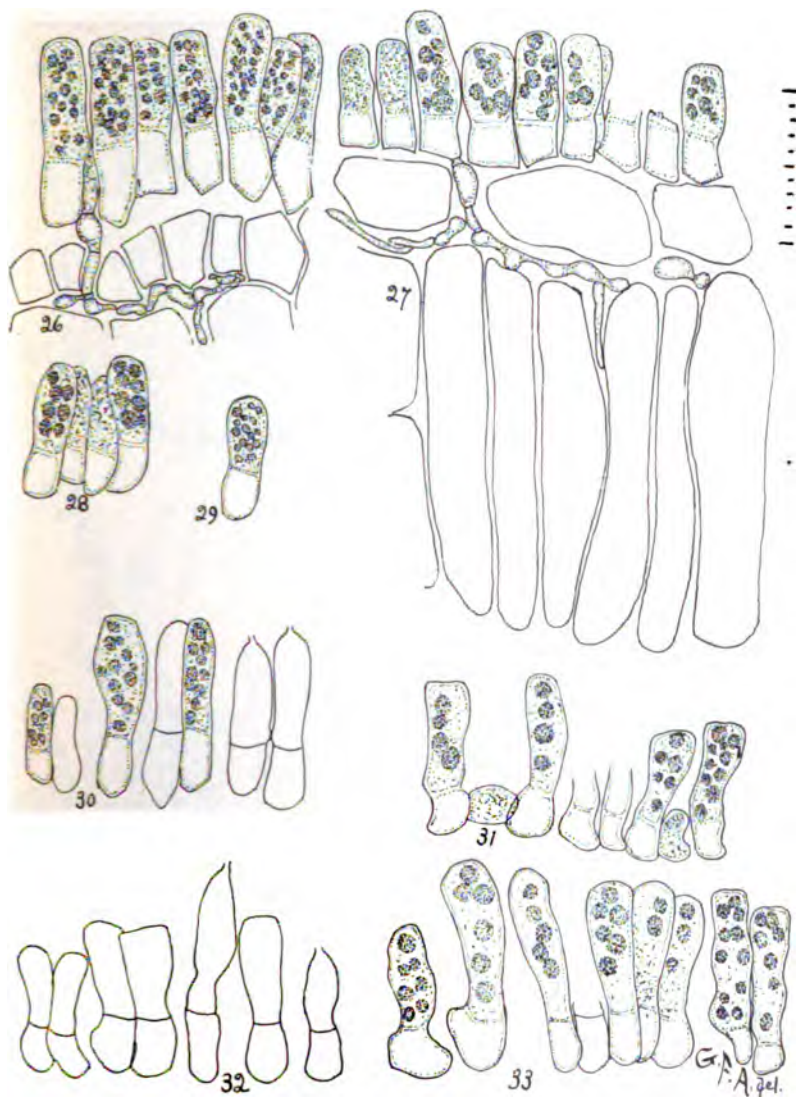


PLATE XI.—Figs. 26-32, *Exoascus varius* Atkinson (on *P. serotina* L.).
Fig. 33, *E. varius* ? (On *P. demissa* Walp.).

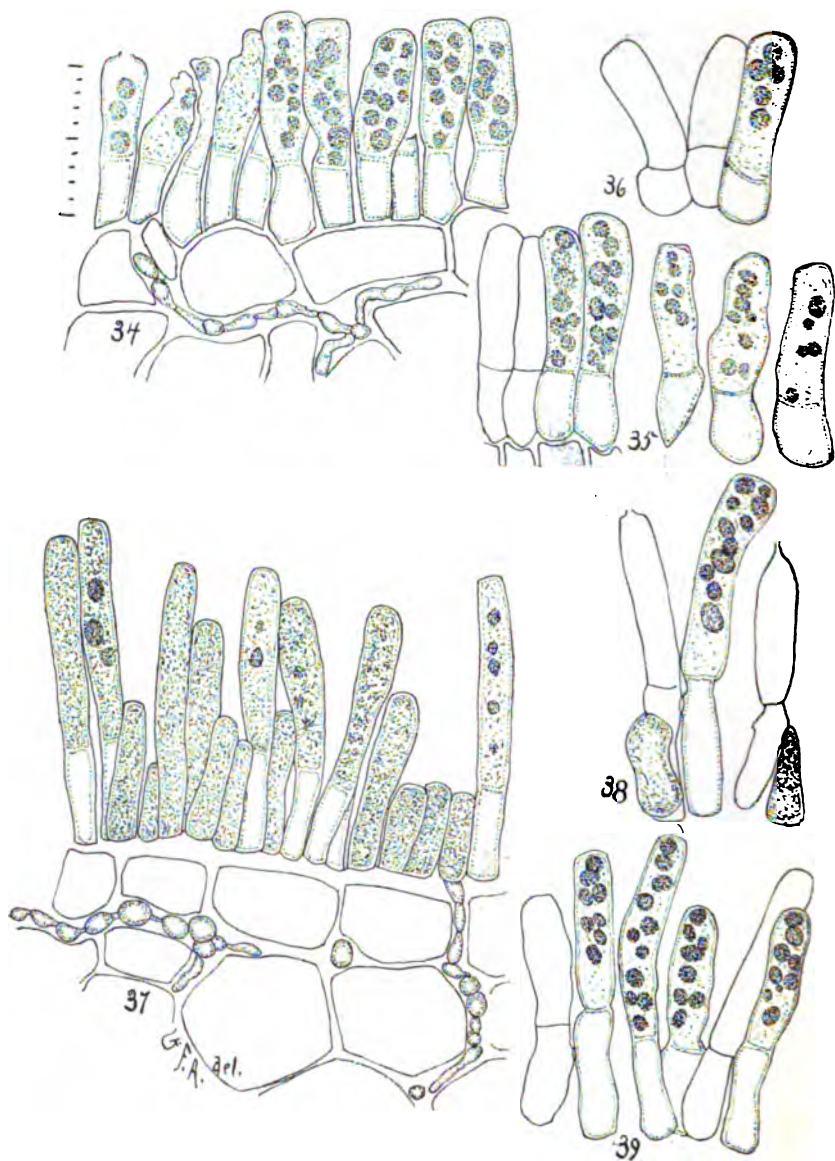


PLATE XII.—Figs. 34-36, *Exoascus farlowii* Sadebeck (on *P. serotina* L.).
Figs. 37-39, *Exoascus confusus* Atkinson (on *P. virginiana* L.)

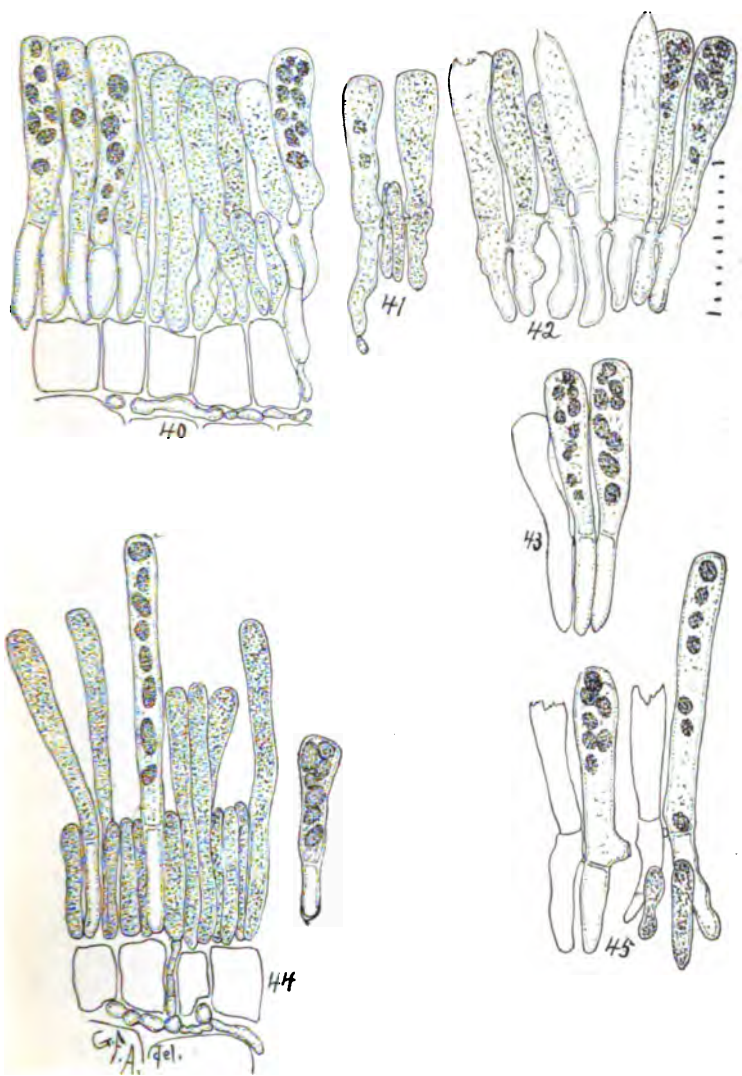


PLATE XIII.—Figs. 40-43, *Exoascus communis* Sadebeck ? or *E. mirabilis* Atkinson var. *tortilis* Atkinson ? (on deformed fruit, *P. americana* Marshall). Figs. 44, 45, *Exoascus pruni* Fuckel (on *P. domestica* L.).

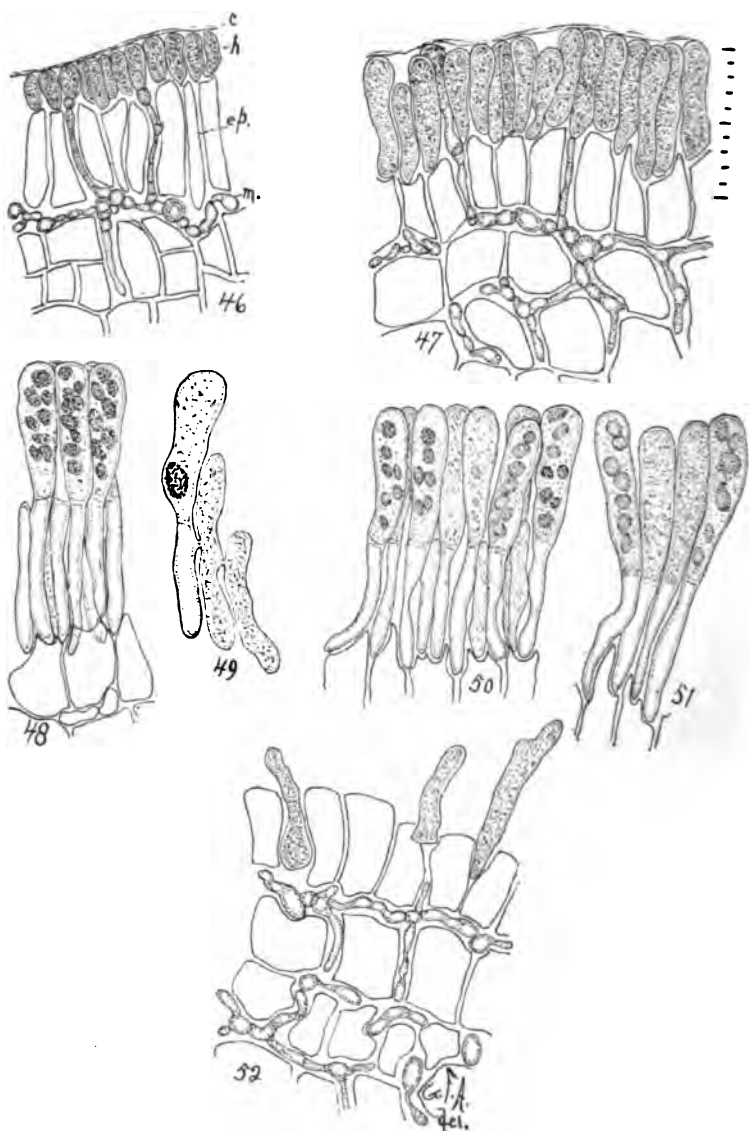


PLATE XIV.—*Exoascus longipes* Atkinson (on *P. americana* Marshall).

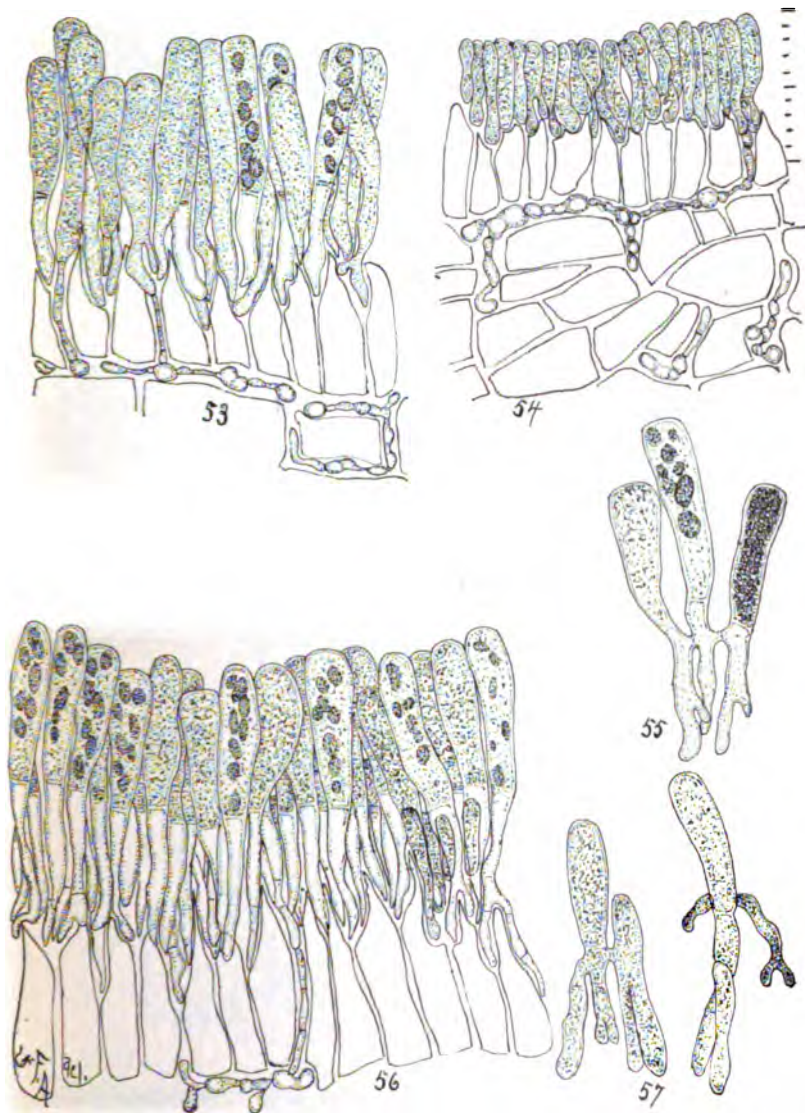


PLATE XV.—*Exoascus rhizipes* Atkinson (on *P. triflora* Roxburgh).

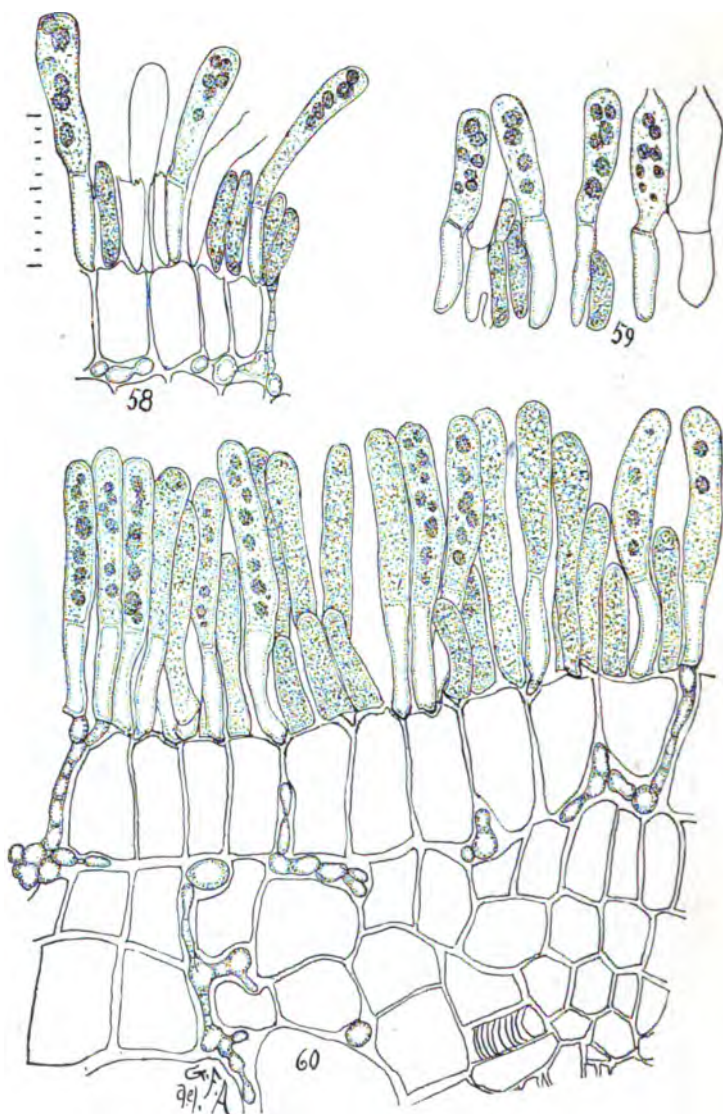


PLATE XVI.—*Exoascus communis* Sadebeck (58, 59 on *P. maritima* Wang.,
60 on *P. nigra* Aiton).

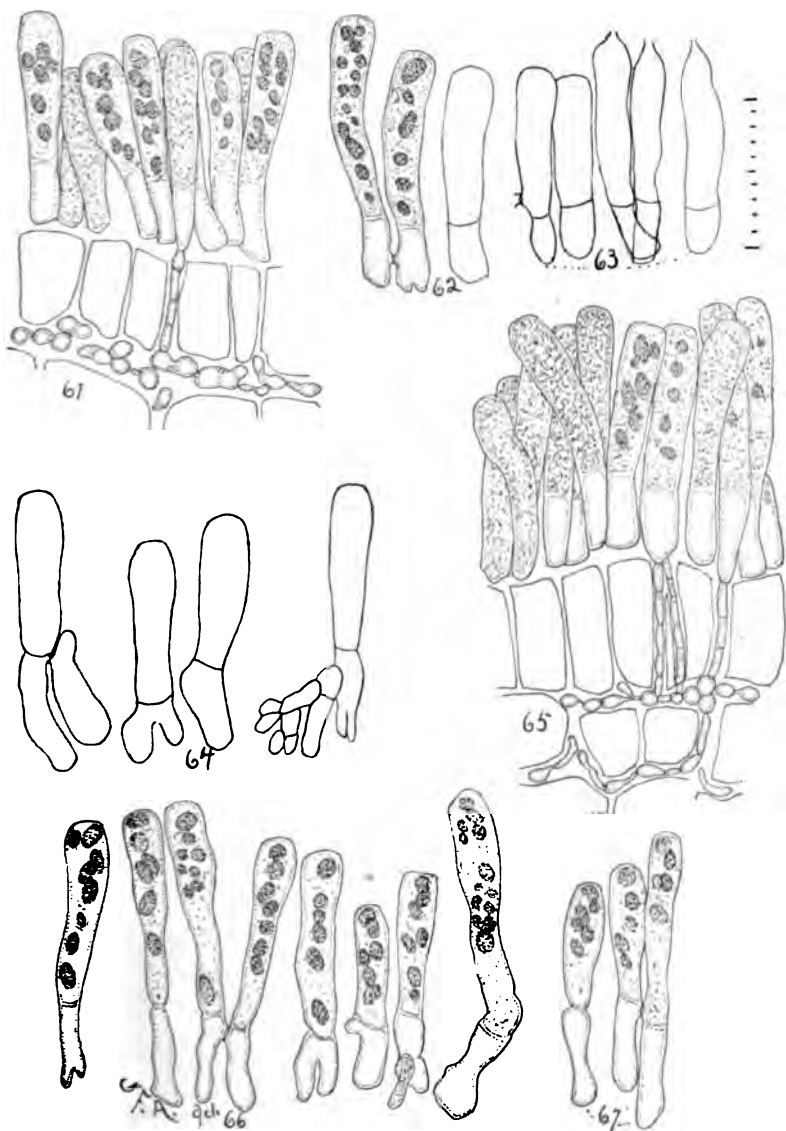


PLATE XVII.—Figs. 61, 62, 63, *Exoascus mirabilis* Atkinson (on *P. angustifolia* Marshall); 66, 67, *E. mirabilis* Atkinson (on *P. americana* Marshall); 64, 65, *E. mirabilis* var. *tortilis* Atkinson (on *P. angustifolia* Marshall).

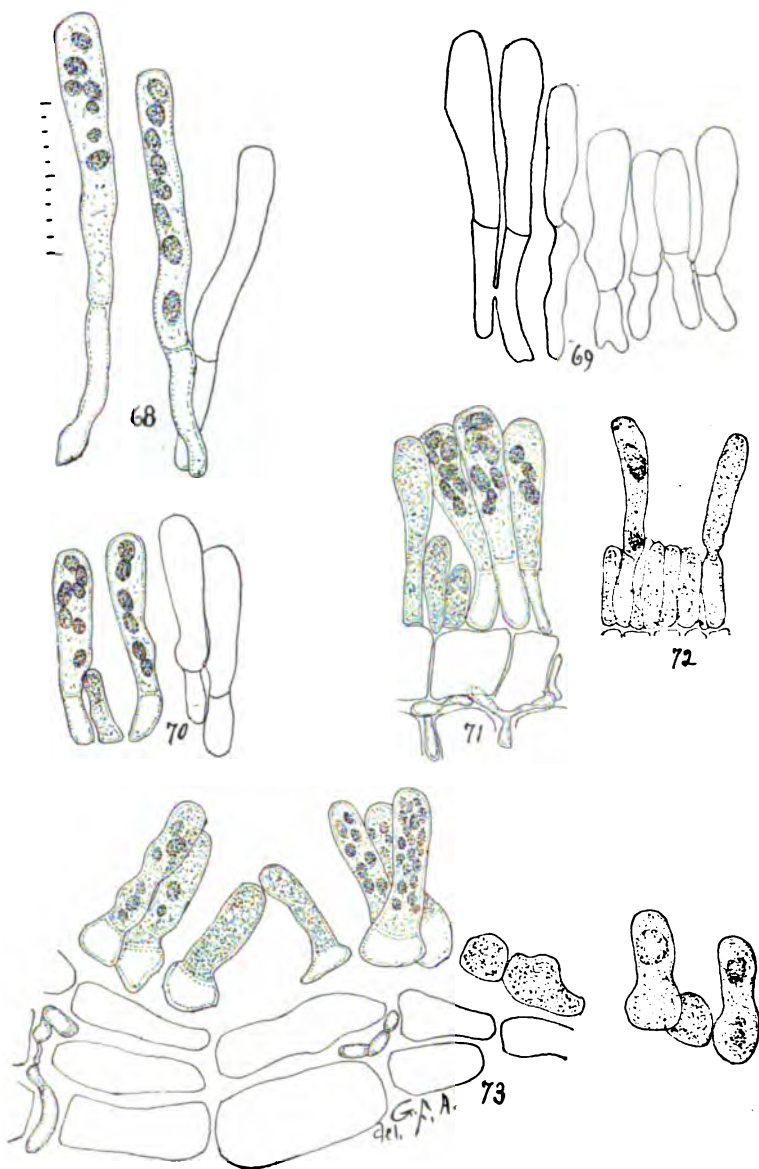
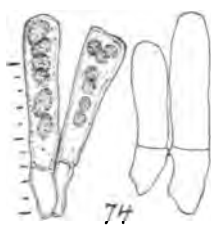
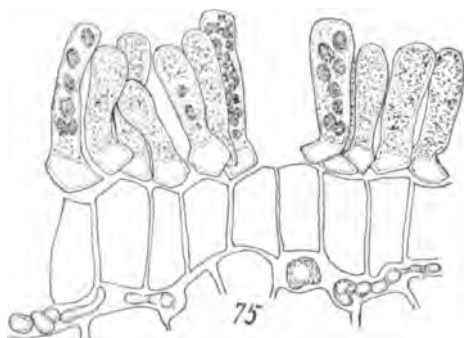


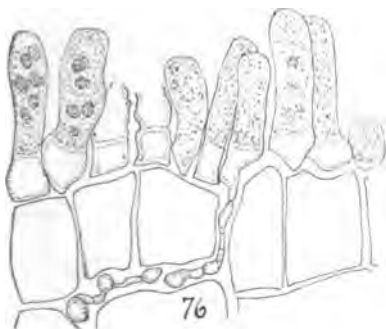
PLATE XVIII.—Figs. 68, 70, 71, 72, *Exoascus mirabilis* Atkinson (on *P. hortulana* L. H. Bailey, 71 on var. *mineri*). 69, *Exoascus* sp. (on shoot of *P. domestica* L.). Fig. 73, *Exoascus cecidomophilus* Atkinson (on *P. virginiana* L.).



74



75



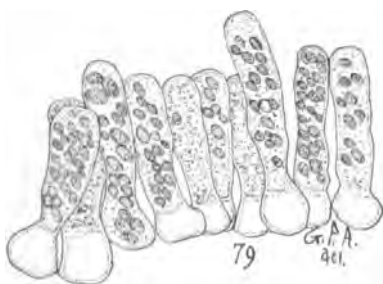
76



77



78



79

G. A. A.
461.

PLATE XIX.—Figs. 74-77, *Exoascus decipiens* Atkinson (on *P. americana* Marshall); 78, 79, *E. cecidomophilus* Atkinson (on *P. virginiana* L.).

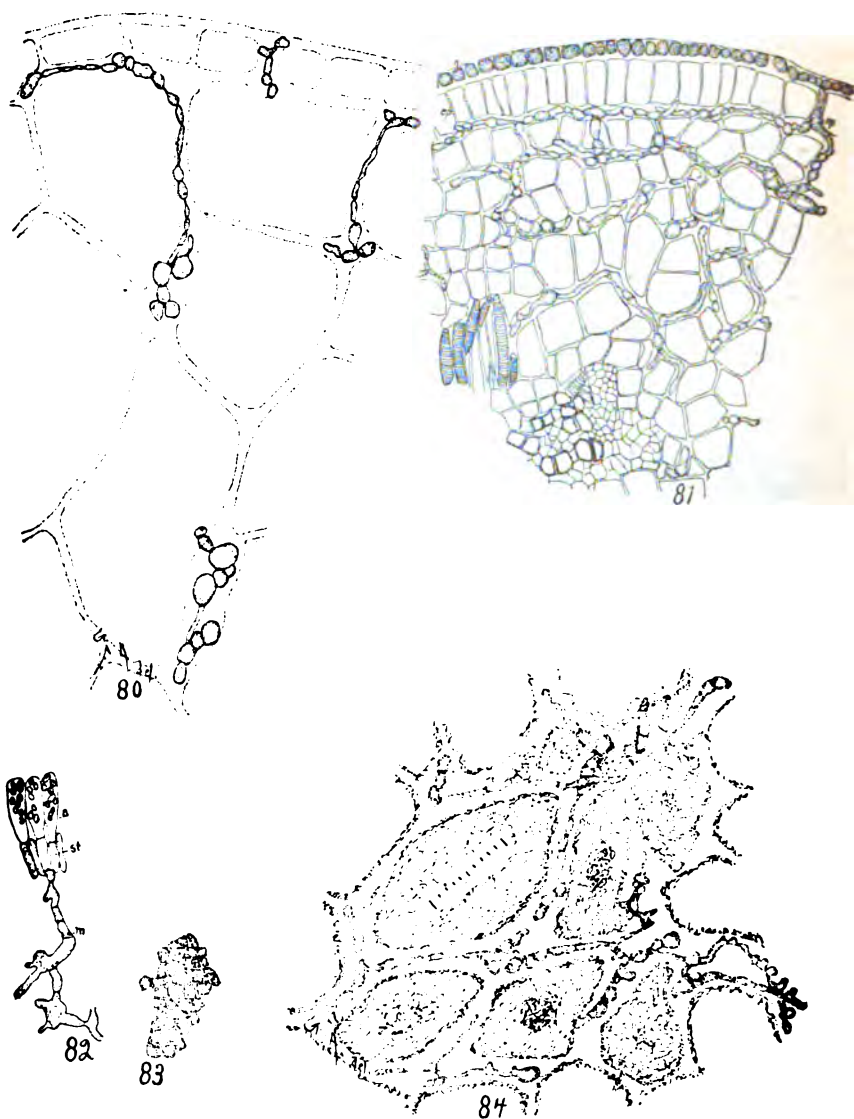


PLATE XX.—Figs. 81, 82, 83. *Exoascus mirabilis* Atkinson (on *P. angustifolia* Marshall); 80, 84, *Exoascus* sp. (on *P. virginiana* L.).

N7
C826

Bulletin 74.

October, 1894.

**Cornell University Agricultural Experiment Station.
HORTICULTURAL DIVISION.**

**IMPRESSIONS OF
THE PEACH INDUSTRY
IN WESTERN NEW YORK.**



By L. H. BAILEY.

**PUBLISHED BY THE UNIVERSITY,
ITHACA, N. Y.
1894.**

ORGANIZATION.

BOARD OF CONTROL:

THE TRUSTEES OF THE UNIVERSITY.

STATION COUNCIL.

President, JACOB GOULD SCHURMAN.

Hon. A. D. WHITE,	-	-	-	-	Trustee of the University.
Hon. JOHN B. DUTCHER,	-	-	-	-	President State Agricultural Society.
Professor I. P. ROBERTS,	-	-	-	-	Agriculture.
Professor G. C. CALDWELL,	-	-	-	-	Chemistry.
Professor JAMES LAW,	-	-	-	-	Veterinary Science.
Professor A. N. PRENTISS,	-	-	-	-	Botany.
Professor J. H. COMSTOCK,	-	-	-	-	Entomology.
Professor L. H. BAILEY,	-	-	-	-	Horticulture.
Professor H. H. WING,	-	-	-	-	Dairy Husbandry.
Professor G. F. ATKINSON,	-	-	-	-	Cryptogamic Botany.

OFFICERS OF THE STATION.

I. P. ROBERTS,	-	-	-	-	-	Director.
E. L. WILLIAMS,	-	-	-	-	-	Treasurer.
H. W. SMITH,	-	-	-	-	-	Clerk.

ASSISTANTS.

M. V. SLINGERLAND,	-	-	-	-	-	Entomology.
GEO. C. WATSON,	-	-	-	-	-	Agriculture.
G. W. CAVANAUGH,	-	-	-	-	-	Chemistry.
E. G. LODEMAN,	-	-	-	-	-	Horticulture.
MICHAEL BARKER,	-	-	-	-	-	Horticulture.

Office of the Director, 20 Morrill Hall.

Those desiring this Bulletin sent to friends will please send us the names of the parties.

BULLETINS OF 1894.

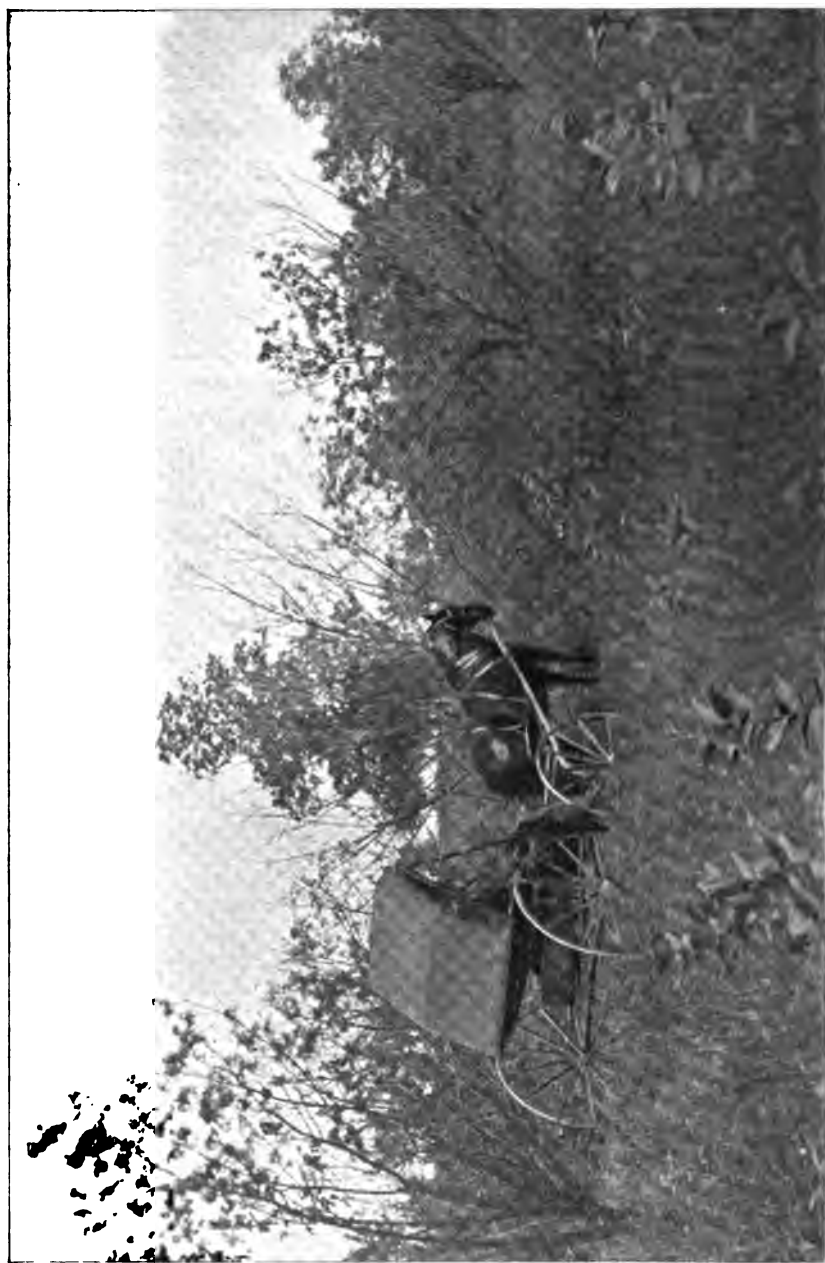
62. The Japanese Plums in North America.
63. Co-operative Test of Sugar Beets.
64. On Certain Grass-Eating Insects.
65. Tuberculosis in Relation to Animal Industry and Public Health.
66. Test of Cream Separators.
67. Some Recent Chinese Vegetables.
68. The Cultivated Poplars.
69. Hints on the Planting of Orchards.
70. The Native Dwarf Cherries.
71. Apricot Growing in Western New York.
72. The Cultivation of Orchards.
73. Leaf Curl and Plum Pockets.
74. Impressions of the Peach Industry in Western New York.

CORNELL UNIVERSITY, ITHACA, N. Y., October 1, 1894.

THE HONORABLE COMMISSIONER OF AGRICULTURE, ALBANY.

Sir: The following review of the condition of the peach industry in the Fifth Judicial Department of the state, is submitted for publication under Section 87, Chapter 675, of the laws of 1894. Various experiments in the treatment of peach diseases and in the fertilizing of peach orchard lands are now under way.

L. H. BAILEY.



Timothy Yellow.—"Peaches don't pay." (Page 374.)

PEACHES. IN WESTERN NEW YORK.

I. GENERAL REMARKS.



ABOUT 9,000 acres are devoted to commercial peach orchards in western New York,—that region from Cayuga and Tompkins counties westward. There are small peach orchards scattered throughout the greater part of this area, except in the southern tier of counties, but the major part of the peach industry is comprised in the Niagara-Ontario district, beginning at Lewiston just north of Niagara Falls, and running eastward along the Ontario slope nearly to Rochester. This district lies in the counties of Niagara and Orleans. There are about 5,000 acres of peach orchard in Niagara county and about 1,000 in Orleans. These orchards, for the most part, lie to the north of the Ridge, which is a natural elevation or embankment lying from five to eight miles back from the lake. The second largest peach district in western New York lies about Seneca Lake. Here there are about 1,000 acres of peach orchards. There are about 400 acres in Livingston county, mostly on the gravelly hills about Mt. Morris; and at this place is the largest peach orchard which I know in the state, that of John F. White, comprising 200 acres. On Keuka Lake there are about 300 acres of peaches, and on Cayuga something less than 200 acres.

After having made a careful study of the horticulture of New York state, I am convinced that the peach industry suffers more from careless and unscientific methods than any other pomological interest. The greatest fault lies in the cultivation, or, I might have said, in the lack of cultivation. The second fault is inattention to borers and yellows; the third is neglect to

thin the fruit ; and the fourth is carelessness and untidiness in marketing. There are many orchards in western New York which receive every care and attention, but by far the greater number are neglected in one or many respects. I have attempted, during the past summer, to examine carefully every peach district in the Fifth Judicial Department, and I shall here attempt to set down what appear to be the chief defects in our peach industry.

Locations and soils for peaches.—There is much territory in western New York which is admirably adapted to peach growing, but which is now used for other purposes. The slopes adjoining the interior lakes are, no doubt, capable of great development in this direction, for here the severities of winter are tempered and serious late spring frosts are infrequent. The industry could be extended to several times its present dimensions in the Niagara-Ontario district ; and the higher and looser lands in some interior sections are well adapted to the peach. The Chautauqua district, lying against the eastern end of Lake Erie and now given over very largely to the growing of grapes, is also, no doubt, naturally well suited to peach raising. A conservative estimate would place the lands of western New York which are well adapted to the peach at 60,000 acres.

On the other hand, many of the peach orchards of western New York are planted upon land which is wholly unsuited to them, such as heavy clay soils, or low lands which have very imperfect drainage of both water and air. The ideal peach soil is a deep sand. Upon such lands the trees make a hard growth, the wood matures early, the trees bear young and the fruit is highly colored and flavored. The regions which have become most famous as peach growing centers are those of a sandy formation, as the lands of many parts of the south, of Delaware and New Jersey, and of the "peach belt" on the eastern shore of Lake Michigan. Some of the best peach orchards which I know are upon lands which were once thought to be worthless ; and the one shown in Fig. 3 stands on sand which, before the orchard was set, was so loose that it drifted in the wind. Warm sandy lands abound along the Ontario shore, and it is upon them that the peach orchards of that region are giving the best returns. Yet, peaches will thrive upon heavier lands, even upon clay ; but they are rarely

so productive upon heavy lands unless they are severely headed in. Upon such lands the trees run strongly to wood and they often split down from the weight of foliage alone, when disturbed by wind. The shaley or gravelly slopes about the central New York lakes are generally well adapted to the peach; and there is a line of morainic hills in western New York which could probably be planted to peaches with eminent success. In interior localities—away from the lakes—it is generally only upon elevated land that peaches thrive. These are lands which are naturally well drained and they escape the late spring frosts which are frequently so disastrous to peach buds in lower places. It is sometimes said that in these interior places trees should not be set upon southern exposures, for in such places the buds are likely to start too early in spring. This is no doubt good advice; but it should be understood that it may not apply to lands within the influence of bodies of water of considerable size. The areas about the interior lakes which are safe for peaches are usually only a mile or two wide and sometimes they appear to be confined to the farms which lie directly on the shore. The once famous peach district of the eastern shore of Cayuga Lake was confined within a strip three or four miles wide.

Cultivation and fertilizing of the peach orchard.—Having selected his land, the peach grower must look with the greatest care to the cultivation and fertilizing of his orchard. Peach orchards should never be cropped after the third year; and if they are planted upon sandy lands, which are best adapted to them, and particularly if set less than 20 feet apart, they should never be cropped from the time they are set. The tillage described in Bulletin 72 is the only reasonable treatment for the land in a peach orchard,—very frequent stirring of the surface soil from May until August, and thereafter, perhaps, a green crop, which shall be plowed under the next spring. Never, under any circumstances, seed down a peach orchard! Never sow it to grain! Lack of tillage is ruinous, and I am astonished that farmers do not see this fact when bewailing the unprofitableness of their sod-bound, drouth-sick and borer-cursed orchards! If there is any fruit which should never be neglected, it is the peach; and this is why careless men do not succeed with it, and why so many of the

orchards which I have seen this summer produce only debts and exasperation.

But here comes a difficulty : it is easy to produce an overgrowth upon strong lands. The trees grow to a great size during the first few years, their tops are full of heavy leaves and the foliage holds very late in the fall. These trees generally bear tardily and



1. *Michigan peach orchard eight years old, with vase-form trees.*

in some cases they are never very productive of fruit. They run to wood. The winds tear them to pieces. The first trouble lies in the land ; it is too strong for the peach. The second trouble may be the too free use of barn manures or other nitrogenous fertilizers, or too late cultivation in the fall. In 1889 I set several varieties of peaches in the University gardens upon soil which had been well manured in previous years, and the land has since been used for garden vegetables which have been well and sometimes even excessively manured with stable manure. The trees have now passed their sixth summer, but not one of them has borne two dozen peaches. Yet they are models of thrift, and the

large heavy leaves are as green this middle of October as they were in June. Some of them have been entirely ruined by storms, and now the lustiest one of the lot has got the yellows !

I believe that the key-note to the proper fertilizing of peach orchards is potash and phosphoric acid and not nitrogen. Ashes, muriate of potash, bone fertilizers,—these are some of the money-makers for peach trees. Tillage, with green manure crops at the end of the season, can be relied upon to furnish the nitrogen in most instances ; and I am not sure but that it is even possible to plow under too much vetch or crimson clover in the course of years. We have been taught all along that nitrogen lies at the foundation of successful agri-



2. *Vase-form tree, 10 years old. From life. (Michigan.)*

culture, and this is true ; but its greatest benefits, when it is applied artificially, are to be expected upon the annual crops of the farm and garden. It can also be applied advantageously, in some cases, to newly-set fruit plantations. I do not wish to disparage the use of nitrogen, for even in bearing orchards a direct application may sometimes be necessary ; but I desire to state what I believe to be a fundamental consideration in orchard culture, that nitrogen can easily be used to excess and that it can generally be obtained by means of tillage and green manure, and also that potash and phosphoric acid need to be annually applied to orchards of bearing age.

There are direct experiments which show the effects of various fertilizers upon the peach. These were made upon an extensive

base by Dr. E. F. Smith when studying the relation of fertility to peach yellows. The effect of the fertilizers upon the trees was incidental to the subject in hand, but the record* of the investigation is valuable to those who are interested in fertilizing peach lands, as well as those who are studying the yellows. It was found that the nitrogenous manures produce quick results, whilst the potassium and phosphorous generally show their effects more plainly the second or third years. The following citation will show the effect of a nitrogenous fertilizer in stimulating growth and delaying maturity :

Eighty-four trees received Peruvian guano at the rate of 12 lbs. per tree on April 25, 1889. On August 22, 1889, the trees were found to have "made a most astonishing growth. * * The maturity of the season's growth has been retarded and the energy of the trees has gone to the production of an excessive amount of wood and foliage. The latter is now so abundant and so green that the block can be distinguished readily one-half mile away.

* * Some of the trees bore a few peaches, and the effect of the guano was to retard maturity. The fruit was also inferior, and some of it withered green instead of ripening, a fact never before observed in this orchard."

Pruning peach trees.—The methods of pruning peach trees are the occasion of much discussion amongst pomologists. The differences of opinion turn chiefly about three practices,—short trunks with rapidly ascending branches, high trunks with more horizontal branches, and shortening in or heading back the annual growth. Each of these three methods of handling or training peach trees has ardent advocates and pronounced opponents. It is probable that each system has distinct merits for particular cases. I believe that the nature and fertility of the soil are the dominating factors in these opposing methods. A system of pruning which fits the slow growth and hard wood of sandy soils may not be adapted to the rapid growth and heavier tops of trees on strong soils. Fig. 1 shows what I believe to be, in general, the best method of pruning peach trees upon sandy or what may be called peach soils. It is the natural method. The tree is allowed to spread

* Experiments with Fertilizers for the Prevention and Cure of Peach Yellows. Bull. 4, Div. Veg. Pathology, Dept. Agric.

its top at will with no heading in. The foliage is comparatively light and does not place great weight upon the branches, and the trees, upon such lands, do not grow quickly to such great size as upon heavy lands. This method of allowing a tree to make its natural top, is the common one in the Chesapeake peninsula (Fig. 4) and in the Michigan peach belt (Figs. 1, 2, 3). It will be



3. *Vase-form trees, six years planted. (Michigan.)*

observed, also, that the pictures to which I have referred show trees with short trunks and forking branches. It is a prevalent opinion in this state that such trees are more likely to split down with loads of fruit than those which have more horizontal branches (as in Figs. 5 and 6), but I think this to be an error. Of course, some care should be exercised to see that the branches do not start off from the trunk at exactly the same height, thus making a true fork or Y. With this precaution, the crotch trees are no more likely to split than the others, while they allow of a much better form of top, unless the tree is to be headed in. I have taken particular pains this year to observe the breaking of loaded peach trees, and I find that the limbs much oftener break

in two than they split at a crotch, and orchards in which the trees are pruned after the manner of Figs. 1 to 4 have in no case suffered more than others. In fact, the horizontal branches of the high-topped trees often appear to carry a load of fruit with less ease than the more upright branches of the other style of training. This danger of breaking is greatly lessened if the fruit is



4. Vase-form trees, six years planted. (Maryland.)*

properly thinned. The low trunk allows of a more open top, and this seems to be an advantage. One is often surprised at the thinness of top in the best peach orchards of Delaware and Michigan. In such tops, the peach should color up better, and it is reasonable to expect less trouble from fungi.

* For a contrast of the Michigan and Chesapeake methods, with an account of variations in the sizes of the trees, see *American Garden*, 1890, 20.

Yet there is much to be said, fairly, for the high-topped trees. They are more easy to till and it is quite as easy to pick their fruit; and there is less tendency to make long and sprawling branches as a result of careless pruning. On rich lands, it is perhaps the better method. And here is the chief reason for heading back in this climate,—the necessity of checking the growth and keeping the tree within bounds when it is growing in a strong soil. Whether one shall head in his trees or not, therefore, must depend entirely on circumstances. In sandy peach lands it is generally unnecessary, but it may be a good practice when trees make an over-exuberant growth. This heading in is usually done in the winter, from a third to half the annual growth being removed. It is sometimes done also in the summer, but it is very doubtful if this is a wise practice. Fig. 6 shows an orchard a dozen years old which has been headed in both winter and summer for a number of years. The summer trimming is usually made in June, by clipping off an inch or two of the ends of the tender shoots by means of a sickle or sword.

Heading in the branches always makes a thick-topped tree. The Michigan growers usually give much attention to cutting out the small unprofitable wood from the center of the tree. This labor may be greatly increased if heading in is practiced. Many orchards of this state have suffered much during the last two years from twig-blight in these central shoots. This difficulty is discussed farther on (page 379, Fig. 8).

Thinning the fruit.—There is almost universal neglect in thinning the fruit in this state. Every peach grower knows that good fruit cannot be grown upon overloaded trees, and yet he refuses to thin and forthwith blames the market! It should be a rule that no two peaches should stand closer together than five inches of one another. The spray upon the title-page shows, approximately, the distance at which peaches should stand apart. No work of the orchard pays better than this thinning of the fruit, either in the price which the remaining produce brings in the market or in the vital energy which is saved to the tree. Peach trees which are regularly thinned should bear every year, barring injuries from winter or spring frosts. Growers seem to forget that this fruit must all be picked sooner or later, and that the work is

more easily done in June or July than in September. The thinning should be delayed until the fruit is the size of the end of one's thumb, for by this time the "June drop" (see p. 383) has occurred, and the peaches can be readily seen and handled.

Marketing the fruit.—But if growers are negligent in thinning the fruit, they are too often positively careless in marketing it. Even in this year of low prices, fancily or nicely packed fruit has brought good prices, wholly independent of its quality. The hand-



5. *Peach orchard with long trunks and round-head training. (Michigan.)*

some boxes of California peaches, containing 60 wrapped fruits, have sold from \$2.00 to \$4.00, and yet they are generally very inferior in quality when they reach our markets. Alongside these peaches, shipped several thousand miles, our peaches have sold for 25 cents to 75 cents a half bushel.

There are several faults with our method of handling peaches. The packages are too large. The fruit is not graded and selected; in fact, it is not well grown. There are often no wooden covers on the baskets, and, as a consequence, that part of the package which should look the best is usually the most jammed and crushed. In observing the markets this summer, I found that quite half the packages were not full when they reached the sales-

man and the peaches comprising the two or three top layers had chased each other around the basket until they were scarcely recognizable. The peaches had evidently been dumped into the

6. *High-topped trees, shortened in each year. (Geneva, New York.)*



basket and they settled as soon as placed upon the cars. Our method of handling peaches is the very best advertisement of the handsome Pacific coast fruit. In that fruit, every individual peach is sound and perfect; in eastern fruit, the peaches often run through the package and are sold in the liquid state !

Varieties.—Amongst varieties, the Melocoton family is still the most prominent in western New York. The old Red-Cheek Melocoton, from which the family sprung—or at least, varieties under that name—is occasionally seen and recommended, but it is doubtful if the original form of it is now known. This important family of peaches is known by a firm yellow flesh, free stone, red-splashed cheek, and a prominent tip-like projection at the apex. Its chief representatives now-a-days are the Early and Late Crawford. Some orchards are composed almost entirely of these varieties, particularly in Niagara county, although there are several somewhat differing forms or strains under each name. I am inclined to think that the Crawfords are planted too exclusively and that the time has come for the freer introduction of other sorts. Amongst recent varieties of this type, the Brigdon or Garfield receives most praise in western New York, although Foster and Chair's Choice are popular wherever known. Although the white-fleshed peaches, as a class, are superior in quality to the yellow-fleshed, yet consumers demand the yellow varieties almost exclusively. I have solicited lists of the very best market peaches from well posted men in various parts of western New York, and they are detailed below :

H. S. Anderson, Union Springs, Cayuga Co.—Alexander, Mountain Rose, Early and Late Crawford, Old Mixon Free. To these might be added Wheatland, Wager, Foster and Salway.

S. D. Willard, Geneva, Ontario Co.—Horton's Rivers, Hynes' Surprise, Yellow St. John, Brigdon or Garfield, Red-Cheek Melocoton, Stevens' Rareripec, Willet, Salway. Elberta promises well.

E. Smith & Sons, Geneva.—Atlanta, Yellow St. John, Early Crawford, Brigdon, Potter (new), Lamont (new), Late Crawford, Stevens' Rareripec, Wager.

T. C. Maxwell & Bros., Geneva.—Crosby, Hill's Chili, Elberta, Brigdon or Garfield, Stevens' Rareripec, Red-Cheek Melocoton, and probably a few Early and Late Crawford.

Geo. G. Atwood, Geneva.—Alexander for first early, Early Rivers, Brigdon, Stevens' Rareripec.

C. W. Stuart & Co., Newark, Wayne Co.—Foster, Brigdon, Wheatland, Hill's Chili, Longhurst, Stevens' Rareripec, Wager,

Early Rivers, Early York, Early and Late Crawford, Elberta, Hynes' Surprise, Mountain Rose.

C. H. Perkins, Newark.—Early Michigan, Hale, Early and Late Crawford, Foster, Michigan Chili, Barnard, Wheatland.

Geo. C. Snow, Penn Yan, Yates Co.—Early Rivers, Wager, Yellow Alberge, Hill's Chili, Salway.

John F. White, Mt. Morris, Livingston Co.—Elberta, Foster, Early and Late Crawford, Brigdon, Wheatland,—all yellow. Mountain Rose, Stump, Old Mixon Free, for white.

Dewane Bogue, Medina, Orleans Co.—Lolo, Alexander, Early Rivers, Honest John, Early and Late Crawfords, Foster, Hill's Chili, Old Mixon Free, Morris White, Smock.

Julius Harris, Ridgeway, Orleans Co.—Early and Late Crawfords have been the most profitable varieties with me.

H. H. Bickford, Johnson's Creek, Niagara Co.—I should plant chiefly Early and Late Crawfords. Smock is too late for this locality.

W. T. Mann, Barkers, Niagara Co.—Early and Late Crawford, Foster, Reeve's Favorite. Among white varieties I should choose Mountain Rose, Stump, Old Mixon Free, Ward's Late White. Elberta is promising.

F. M. Bradley, Lake Road, Niagara Co.—Early Crawford is our only peach which can be classed as first for market. Yellow St. John is good. Elberta is promising, but is much subject to curl-leaf.

E. M. Moody, Lockport, Niagara Co.—Early Rivers, Mountain Rose, Early and Late Crawford, Smock, Salway.

Peter S. Tower, Youngstown, Niagara Co.—Early and Late Crawford, Reeve's Favorite, Globe, Smock, Old Mixon Free.

Henry Lutts, Youngstown.—Early Rivers, Hynes' Surprise, Yellow St. John, Early Crawford, Old Mixon Free, Reeve's Favorite, Wheatland, Chair's Choice, Late Crawford, Globe, Beer's Smock, Gary's Hold On, Billyer's Late, Salway.

II. ENEMIES AND DISEASES.

Neglect is the most widespread enemy to peach growing in this state. Not only are neglected orchards more liable than others to the attacks of borers and other pests, but they become weak and stunted through starvation. Sod-bound peach orchards are always poor and unprofitable. They have what Professor Roberts calls "timothy yellows," a condition which is far more serious in this state than the true and much-dreaded yellows. The frontispiece shows an orchard which "somehow hain't done well." The trouble is that the owner has tried to raise timothy, sumac, briars and peaches all at the same time. The trees, in the vigor of their youth, bore one crop, "but then they seemed to get the yellows." But it is timothy yellows only. An examination of the orchard, covering many acres, did not reveal a single specimen of the yellows, although nearly all the fruit ripened prematurely and never attained more than half the normal size. But it was as well as trees on one-fourth rations and boarding an army of borers at the same time could be expected to do.

This picture calls to mind the history of the perishing peach industry of the eastern slope of Cayuga Lake; and this history may be taken as a type of the failure of the peach in many parts of the north. "A generation and more ago, peaches were plenty here, but now we cannot grow them." This I hear everywhere,—in Michigan, Ohio, New York and New England. There are many theories to account for this failure. Oftenest, perhaps, it is attributed to change of climate, but we have no proof that any considerable climatic change has occurred, while it seems to be true that the northern peach frontier is holding its own or is even advancing. In New York, the failure is often attributed to yellows, that disease which seems to exist as a vague and indefinable alarm in the minds of the general agricultural population. Yellows is said to have wiped out the peach growing of the Cayuga belt, and it was with much curiosity that I undertook an exploration of this region the present summer. Twenty years ago a million peach trees, it is said, could be seen upon the eastern shore from one point upon the west side, but now there are only

a few scattered orchards. Here, then, may be found the secret of this strange falling off of the peach trees in all parts of the country in these recent years.

Slanting towards the lake and pouring into it their drainage of water and cold air, laterally drained by deep ravines and protected from sweeping winds by lines of wood, these Cayuga lands seem to be admirably adapted to the peach. But I found that the region had never been a peach belt, in the sense in which that term will apply to the best part of the Niagara district or to the Lake Michigan belt. In other words, peaches had never been a leading industry there, but the orchards had been planted here and there near the lake as a very minor appendage to the general farming. For a generation or two of trees the insect pests were not common. There were no good markets and the fruit sold as low as twenty-five cents a bushel from the wagon box. In fact, it was grown more for the home supply than with an idea of shipping it to market. Under such conditions, it did not matter if half the crop was wormy or if many trees failed and died each year. Such facts often passed almost unnoticed. The trees bore well, to be sure; but the crop was not measured up in baskets and accounted for in dollars and cents, and under such conditions only the most productive trees left their impress upon the memory. The soils had not undergone such a long system of robbery then as now. When the old orchards wore out, there was no particular incentive to plant more, for there was little money in them. Often the young and energetic men had gone west, there to repeat the history perhaps, and the old people did not care to set orchards. And upon this contracting area, all the borers and other pests which had been bred in the many old orchards now concentrated their energies until they have left scarcely enough trees in some localities upon which to perpetuate their kind. A new country or a new industry is generally free of serious attacks of those insects which follow the crop in older communities. But the foes come in unnoticed and for a time spread unmolestedly, when finally, perhaps almost suddenly, their number becomes so great that they threaten destruction, and the farmer looks on in amazement.

The cause of the failure of these early orchards, therefore, is the

gradual dying out of the old system of agriculture and the coming in of special industries. The methods followed with success a generation and more ago are not profitable in the sharper competitions of the present time. At least, there is not the smallest evidence that there is any unusual or insurmountable difficulty in the way of peach growing in this once famous Cayuga region. What yellows exists seems to have come in very recently. Good cultivation and attention to borers and the other difficulties to which peaches are everywhere subject, will enable the people in that region to grow better orchards than were ever grown there in former times. This statement is proved by the partial success which is even now attending those parts of the seven remaining orchards which are receiving as much as indifferent care.

A very brief enumeration of some of the most serious and widespread insect and fungous troubles of the peach in western New York, will serve to call the attention of peach growers to the dangers which threaten them.*

The common *peach tree borer* is unquestionably the most destructive pest of peach trees in this state. It is particularly abundant in neglected orchards. The "worm" or larva is the offspring of a handsome wasp-like moth which flies only during the day and which lays the egg upon the bark during June, July and August, in this latitude. The eggs are usually laid at or near the surface of the ground, although a crotch or other portion of the tree may be selected. The presence of the borer, which works beneath the bark and in the sapwood, is shown by a great exudation of gum. Many operations are advised with a view of preventing the moths from laying eggs, such as washing the trees with soap or other materials, removing the earth from the base of the trees, hilling up the trees, and applying protecting materials like tarred paper or bandages, but all these methods are uncertain and some of them are perhaps wholly ineffective. The only safe course is to dig the borers out in late spring and in fall. This entails some labor, to be sure; but then, it is the price of peaches!

* For a full description of the yellows, see Bulletin 75.

The fruit bark-beetle or pin-hole borer (*Scolytus rugulosus*) is coming to be a serious pest in this state. The black beetle is only a tenth of an inch long, and it bores through the bark of the trunk and branches of the plum, peach, apricot,



7. Holes of fruit bark-beetle or pin-hole borer (*Scolytus rugulosus*).

cherry, pear, apple, quince and some ornamental trees. It cuts a clean round hole the size of a large pin, and limbs or trunks which are badly attacked look as if they had received a charge of very fine shot. I have been called to see two peach orchards which were supposed to have the yellows, but most, if not all, the difficulty lay in the punctures of these tiny beetles. A piece of a branch from one orchard is shown natural size in Fig. 7. If one looks closely he sees the minute holes, and below them a lump of gum which has oozed from the punctures. Upon the same farm, dead apricot trees were found to be completely riddled by these pests, the entire bark of the trunk being loosened from the wood by the burrowing of the insects.

Here, too, the larvæ or grubs were very abundant, sometimes as many as a dozen being found in a space as large as a dime. In the peach branch (Fig. 7) no larvæ were to be found, and there were rarely any burrowings between the bark and wood. The hole ended in the sapwood and no beetles were

to be found in late September, when I examined the trees. In the apricots the beetles were abundant at this time. But if the insects themselves were not to be found in the peach, the injury was nevertheless serious, for the bark about older punctures was found to be dead in circular patches an inch or two in diameter.

This pestiferous insect is native to Europe. It was first detected in this country at Elmira, N. Y., in 1877 upon peach trees. It is now widely distributed in eastern America.

There are no specific remedies for this insect. Its life history is not well understood. It is commonly supposed, at least in Europe, that it generally attacks the stunted or least vigorous trees, and that good cultivation and fertilizing are the best general preventives of its injuries. It is said that the more thrifty trees pour out so much sap where punctured, that the young cannot develop. This may have been the case with the peach trees of which I have spoken, but the injury to the tree, as I have said, was nevertheless severe. In some cases, at least, which have come under my observation, the trees seemed to have come into their weak condition wholly through the injuries inflicted by this borer. The eggs are laid in the fall and the beetles probably die thereafter. The new beetle emerges from the tree early in spring and reënters very shortly thereafter. If more than one brood occurs in the season it is not positively known. Forbes has suggested that some adhesive poison spray or wash, applied to the trunk and limbs, may lessen the attacks. All seriously diseased trees and branches should certainly be burned. In Europe, the insect is not generally considered to be very serious. It is probably held in check by parasites. Already one and possibly two parasites have been discovered upon it in this country.*

The *curculio* scarcely needs description. Its presence is everywhere known to be inimical to peach culture, and yet probably two-thirds of the peach orchards of western New York are unmolested breeding grounds of the insect. The beetle begins its work of egg-laying about as soon as the petals fall from the peach flowers, raising up the familiar crescent flap on the young fruit, under which an egg is snugly tucked away. The fruits which

*For fuller accounts, see Lintner, N. Y. Rep. iv. 103-107; Forbes, Bull. 15, Ill. Exp. Sta., and 17th Rep. State Entomologist of Ill. (with plate).

are first punctured are likely to drop, but the later ones hang upon the tree and are known by the drops of gum which exude from the punctures. If the egg hatches, the peaches become wormy. It is presumed that the reader is acquainted with the methods of catching the curculio; but it may be said that the operation consists in knocking the insects from the tree by a quick jar or shake, catching them upon a white sheet or in a canvas hopper. The "catcher" most commonly used in western New York (manufactured by J. B. Johnson, Geneva) is a strong cloth hopper mounted upon a wheelbarrow-like frame, and running upon two wheels. The hopper converges into a tin box, into which the curculio roll as they fall upon the hopper. One man wheels the devise, by barrow-like handles, under the tree, then drops the handles and jars the tree; or sometimes two men go with a machine, one wheeling it and the other jarring the trees. There are other devises for catching the cucurlio, but this is the most satisfactory one which I know.

The black peach aphid is a very destructive insect which is widely distributed in the eastern states, and which has been introduced into Niagara County upon nursery stock.* This insect is particularly malicious because, in the most destructive form, it works upon the roots and is therefore out of sight and largely out of reach. It occasionally feeds upon the herbage, and in that case it can be dislodged by kerosene emulsion. Trees which are suffering from the root aphid stop growing or become stunted, and the foliage becomes yellowish. Affected trees may not grow for several years even under good cultivation, and this condition may pass for yellows. I do not know that this insect is yet widespread in this state, but peach growers should be aware of its existence. Introduced trees should be carefully examined for the aphid before they are set, and if the insect is found, the roots should be dipped in kerosene emulsion or tobacco decoction. If the insect becomes established in the orchard, it can be killed, when upon the roots, by digging in a strong dressing of tobacco dust.

Fruit-rot and twig-blight.—Of the fungous diseases of the peach, one of the most serious in western New York is the twig-blight and fruit-rot (due to *Monilia fructigena*). The rotting of the early

* See Cornell Bull. 49, 1892.

peaches on the tree is too familiar to need description, but it is not generally known that this decay is not a normal process and peculiar to the variety, but is caused by a distinct fungous disorder. Very often these same trees which show the fruit-rot, have the young growth blighted, as if attacked by something like pear-

blight. This death of the shoots is due to the same fungus which causes the fruit to rot. The decayed peaches sometimes dry up and hang on the tree, and become a prolific source of infection for the coming year. These mummified peaches can be found in orchards all over the state, even, in many cases, a year following the attack. Fig. 8 shows a twig from the center of a neglected peach tree with four mummy peaches a year old, and the fungus has completely killed the entire shoot. Much small dead wood in the center of the tree tops is the result of this monilia, or fruit-rot fungus. The same fungus attacks the cherry and plum.

8. Peaches of last year's crop still hanging on the tree, attacked by monilia. The branch is dead, from the effects of the fungus. $\frac{1}{2}$ nat. size.

The best economic study of this fungus upon the peach has been made by Professor F. D. Chester, of the Delaware Experiment Station.* He found that the fungus may destroy the flowers in spring, and this injury may pass for the effects of frost. He also found that thorough spraying with copper fungicides greatly reduced the injury. His advice for the treatment of the disease is as follows: 1. Gather and burn all mummified fruit. 2. Early in the spring, before the fruit buds begin to swell, spray the trees with a solution containing 1 lb. of copper sulphate to 25 gals. of

*Bull. XV. Del. Exp. Sta. 10-12; Bull. XIX; Fifth Rep. 53-66.

water. 3. As soon as the fruit buds just begin to swell, spray the trees with Bordeaux mixture or copper carbonate. Follow this by another spraying before the buds open. 4. As soon as the fruit shall have reached full size and begins to show signs of color, make a third application. This should be followed by two or three other applications at close intervals of five or seven days during the ripening period. It will probably not be often necessary to make this late application upon peaches in this state.



9. Mildew patches on young peach.

The *peach mildew* (*Podosphaera oxyacanthæ*) has been serious in various parts of western New York the past season. In the Niagara belt it has attacked Crawford's, and upon Seneca Lake I have seen a peach known as the Denton almost ruined by it. The



10. Black-spot of peach (*Hill's Chili*).

fungus generally appears when the peach is very small, as irregular moldy or frost-like patches upon the surface (Fig. 9). Later on, these patches become brown and hard and the peach cracks. The same mildew also attacks the leaves, covering them with a whitish mold-like substance and causing them to become hard and curled. The fungus is common to many plants

Black-spot.—Another surface fungus which is well known and which has a preference for certain varieties, particularly Hill's Chili, is the black-spot (*Cladosporium carpophilum*). It is usually most serious upon the later varieties. It appears as sooty-black patches of greater or less size, and when the attack is severe the fungus may cover the entire side of the fruit. This side is dwarfed, the flesh becomes hardened, ripens slowly, and deep fissures or cracks appear, sometimes extending through to the pit (Fig. 10). This fungus is usually not sufficiently troublesome in New York to excite general attention, except in certain years and upon particular varieties.

It would seem that the two last diseases should be very easily held in check by a few sprayings with Bordeaux mixture, but the experience of those who have tried it this year has not been reassuring. The chief trouble has been that the fungicide injured the peach foliage. It is well known that peach leaves are very susceptible to any caustic property in spraying mixtures. It is possible that the trouble has been the use of the ferro-cyanide test for making the Bordeaux mixture. This test indicates when sufficient lime has been added to correct the present injurious effects of the sulphate of copper; but in wet seasons—if, in fact, not in all seasons—an extra amount of lime may be needed to neutralize subsequent changes in the compound. I am strongly of the opinion that the regular formula for Bordeaux mixture—6 lbs. lime, 4 lbs. sulphate of copper—is the safest and best one. The mixture may be diluted to any strength required, but for the peach I should not use less than 40 to 50 gallons of water for the above formula.

The leaf curl has been the subject of more concern amongst New York peach growers during the past few years than any other disease, save the yellows. This trouble is fully discussed in reference to its botanical features in Bulletin 73, p. 324. It certainly has a decided preference for some varieties, particularly those with large, soft and dark-colored leaves. It is also influenced greatly by the season, although it is never wholly absent. A moderate attack does not perceptibly injure trees in full vigor. In many cases, however, the larger part of the leaves fall from

the tree in June, and the fruit, deprived of nourishment, may also fall. Leaf curl, the curculio and lack of pollination are the chief causes of the "June drop" of peaches.

There have been few definite experiments in the treatment of the peach curl, but there is reason to believe that one or two very thorough sprayings with sulphate of copper or with Bordeaux mixture before the buds swell, will lessen its spread. A few experiments of this kind in various parts of the country have been successful; amongst these was one made by Henry Lutts, of Youngstown, N. Y.

Root-galls upon the peach, as shown in Fig. 12, have been serious in one orchard in Niagara county, and they are probably widely distributed in the state. These galls occur both upon the small roots several feet from the trunk, and also in large masses just under and about the crown.

Trees thus affected stop growing and assume a yellowish and sickly look, and they may be mistaken for trees suffering with the yellows by persons not familiar with that disease. The cause of this disease is wholly unknown. It occurs from the Atlantic to the Pacific, and Atkinson* considers it to be the same as the *Wurzelkropf* of the Ger-



11. Leaf-curl of the peach.

* *National Nurseryman*, i. 89 (Aug. 1893).

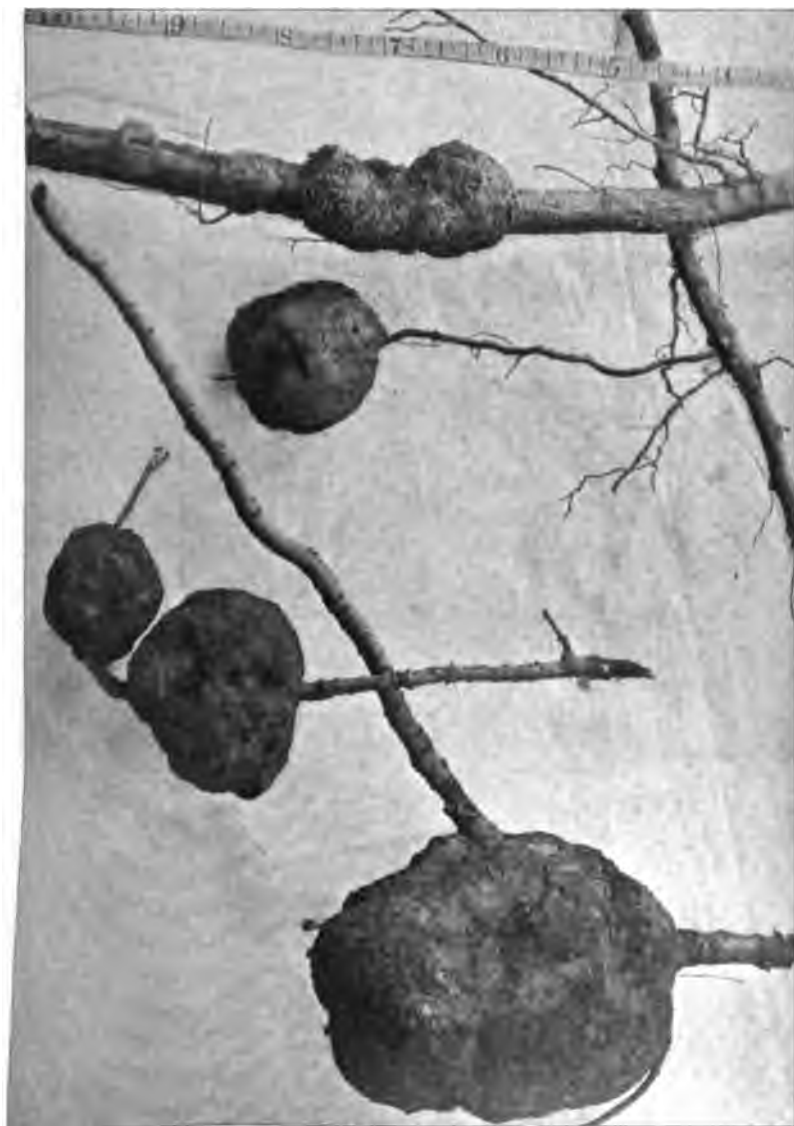
mans. It occurs upon a variety of plants, as raspberries, rose, Marianna plum, pear, apricot and almond; and Wickson and Woodworth report it upon the grape in California. It is said to be very serious upon the Pacific coast. The galls vary in size from that of a pea to twice as large as a man's fist. German writers consider that the disease is due to mechanical injuries of the roots, but this hypothesis is wholly incompatible with the appearance and the spread of the trouble. No investigator has yet been able to discover any insect, fungus or germ to be uniformly associated with the galls. The man in whose orchard I found the galls in Niagara county is convinced that his trees became diseased by growing them in a nursery where infested raspberries were previously grown. The disease is prevalent in our own raspberry plantations at Cornell, and we are able to keep it in check only by pulling up and burning all suspected plants. If berries are affected by this trouble, I should advise destroying the plantation and setting another upon non-infested ground. This disease must not be confounded with the root-knot of the peach and other plants in warm climates and in greenhouses, which is the work of a nematode worm.*

This root-gall has been studied by Professor Woodworth of California,† who gives the following advice: "1. In the orchard the knots should be carefully removed and burned as soon as found, and an antiseptic application made to the tree where the knot has been removed. We would recommend Bordeaux mixture for this purpose. Trees so treated should be examined from time to time for at least a year, and should the knot reappear, it would be best to remove and destroy the whole tree. When a tree is removed, it would be well to delay resetting for a year or two, or to reset with a tree of unsusceptible kind. 2. When setting an orchard, reject all stock affected by the knot. I would prefer to have stock from a nursery known to be entirely free from it. 3. In the nursery, the greatest care should be taken to destroy, by

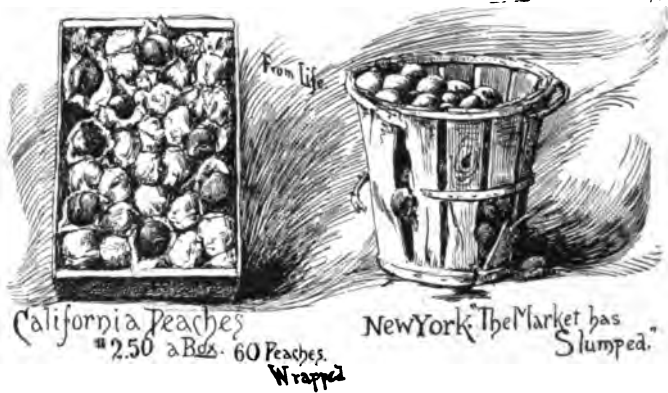
* An illustration and account of the nematode upon winter tomatoes, will be found in our Bulletin 43.

† Bull. 99, Cal. Exp. Sta. (Dec. 1, 1892). See also E. F. Smith, Jour. Mycology, vii. 93; Bull. Torr. Bot. Club, xx. 363.

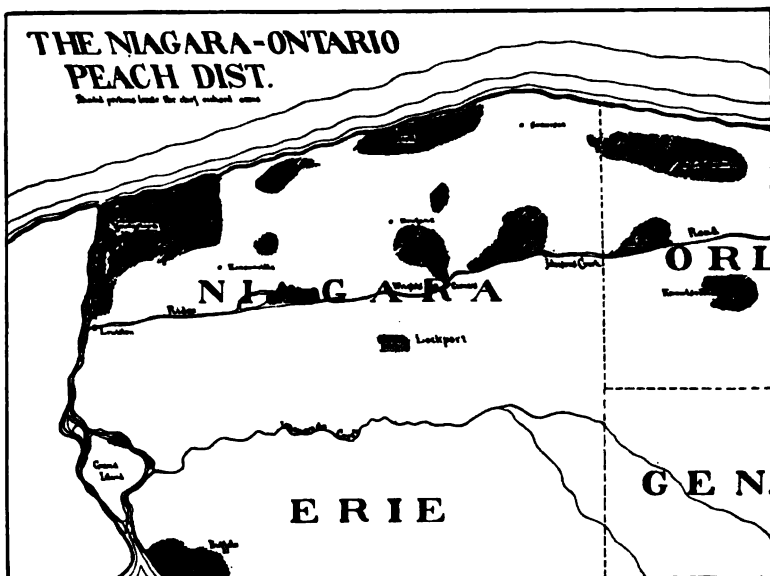
12. Root-galls of the peach. An obscure disease affecting the roots of the peach and various other fruits.



burning, everything showing any evidence of the disease. Fields in which these galls have appeared should be devoted to some other crop for a number of years."







*The shaded portions in the above map show the chief peach-orchard areas in
Niagara and Orleans counties*

N7
C826
Bulletin 75.

October, 1894.

Cornell University Agricultural Experiment Station.

HORTICULTURAL DIVISION.

PEACH YELLOWS.



By L. H. BAILEY.

PUBLISHED BY THE UNIVERSITY,

ITHACA, N. Y.

1894.

ORGANIZATION.

BOARD OF CONTROL: THE TRUSTEES OF THE UNIVERSITY.

STATION COUNCIL.

President, JACOB GOULD SCHURMAN.

Hon. A. D. WHITE,	-	-	-	-	-	Trustee of the University.
Hon. JOHN B. DUTCHER,	-	-	-	-	-	President State Agricultural Society.
Professor I. P. ROBERTS,	-	-	-	-	-	Agriculture.
Professor G. C. CALDWELL,	-	-	-	-	-	Chemistry.
Professor JAMES LAW,	-	-	-	-	-	Veterinary Science.
Professor A. N. PRENTISS,	-	-	-	-	-	Botany.
Professor J. H. COMSTOCK,	-	-	-	-	-	Entomology.
Professor L. H. BAILEY,	-	-	-	-	-	Horticulture.
Professor H. H. WING,	-	-	-	-	-	Dairy Husbandry.
Professor G. F. ATKINSON,	-	-	-	-	-	Cryptogamic Botany.

OFFICERS OF THE STATION.

I. P. ROBERTS,	-	-	-	-	-	Director.
E. L. WILLIAMS,	-	-	-	-	-	Treasurer.
H. W. SMITH,	-	-	-	-	-	Clerk.

ASSISTANTS.

M. V. SLINGERLAND,	-	-	-	-	-	Entomology.
GEO. C. WATSON,	-	-	-	-	-	Agriculture.
G. W. Cavanaugh,	-	-	-	-	-	Chemistry.
E. G. LODEMAN,	-	-	-	-	-	Horticulture.
MICHAEL BARKER,	-	-	-	-	-	Horticulture.

Office of the Director, 20 Morrill Hall.

Those desiring this Bulletin sent to friends will please send us the names of the parties.

BULLETINS OF 1894.

62. The Japanese Plums in North America.
63. Co-operative Test of Sugar Beets.
64. On Certain Grass-Eating Insects.
65. Tuberculosis in Relation to Animal Industry and Public Health.
66. Test of Cream Separators.
67. Some Recent Chinese Vegetables.
68. The Cultivated Poplars.
69. Hints on the Planting of Orchards.
70. The Native Dwarf Cherries.
71. Apricot Growing in Western New York.
72. The Cultivation of Orchards.
73. Leaf Curl and Plum Pockets.
74. Impressions of the Peach Industry in Western New York.
75. Peach Yellows.

CORNELL UNIVERSITY, ITHACA, N. Y., Oct. 10, 1894.
THE HONORABLE COMMISSIONER OF AGRICULTURE, ALBANY.

Sir: This account of the yellows of the peach—probably the most serious and obscure disease of New York orchards—is submitted for publication and distribution in accordance with Chapter 675, Section 87, of the laws of 1894. There has been much inquiry concerning this disease during the present season, and I have endeavored to examine all orchards in western New York from which complaint of yellows has come.

L. H. BAILEY.

NEW YORK YELLOWS AND BLACK-KNOT LAW.

Article 5, Chapter 338, Laws of 1893.

Section 82. The prevention of disease in fruit trees.—No person shall knowingly or willfully keep any peach, almond, apricot or nectarine tree affected with a contagious disease known as yellows, or offer for sale or shipment, or sell or ship to others any of the fruit thereof. Nor shall any person knowingly or willfully keep any plum, cherry or other trees infected with the contagious disease or fungus, known as black-knot. Every such tree and the fruit of a tree infected with yellows shall be a public nuisance, and no damages shall be awarded for entering upon premises and destroying such trees and fruit if infected with yellows or for cutting away the diseased part of any tree infected with black-knot or altogether destroying such tree if necessary to suppress such disease, if done in accordance with the provisions of this article. Every person when he becomes aware of the existence of such disease in any tree or fruit owned by him, shall forthwith destroy or cause such tree or fruit to be destroyed or the infected part to be cut away.

§ 83. Appointment and duties of the agent of the commissioner of agriculture.—When the commissioner of agriculture knows and has reason to believe that any such contagious disease exists, or that there is good reason to believe it exists, or danger is justly apprehended of its introduction in any town or city in the state, he shall forthwith appoint a competent freeholder of such town or city as his agent, who shall hold office during his pleasure and who shall within ten days after his appointment, file an acceptance of the appointment, with the constitutional oath of office, in the office of the town clerk of the town. Such agent shall on or without complaint, whenever it comes to his notice that either of the diseases known as yellows or black-knot exists or is supposed to exist within the limits of the town or city, proceed without delay to examine the trees or fruit supposed to be infected, and if the disease is found to exist, a distinguishing mark shall be placed upon the diseased trees. If the disease is the black-knot, such distinguishing mark shall be placed on some affected part of the trees, or if in the judgment of such agent any such trees should be entirely destroyed, then the trunk of such tree shall be thoroughly girdled, and thereupon the owner notified personally, or by a written notice signed by such agent and left at his usual place of residence, or if a non-resident by leaving the notice with the person in charge of the trees or fruit, or in whose possession they may be. Such notice shall contain a statement of all the facts found to exist, with an order to effectually remove and destroy by fire or otherwise the trees or parts of trees so marked and designated, within ten days, Sundays excepted, from the day of the service of the notice. In case of fruit so infected, the notice shall require the person in whose possession or control it is found, to immediately destroy the same or cause it to be done.

§ 84. Proceedings in case of owner's failure to destroy.—If any person shall refuse or neglect to comply with the order of such agent to remove and destroy trees or parts of trees so marked by him, such agent shall cause such trees or parts of trees to be removed and destroyed forthwith, employing all necessary assistance for that purpose; and such agent or his employees may enter upon any and all premises within the town or city for the purpose of such removal and destruction. Such agent shall be entitled to compensation for his services under this and the preceding sections at a rate of two dollars for each full day spent by him in the discharge of his duties, and the necessary disbursements paid or incurred by him, which with the expense and removal and destruction of any such trees or fruit shall be a town charge.



PEACH YELLOWS.

HERE is no disease or difficulty of fruit trees in New York state which is the subject of so much misapprehension as the yellows of the peach. Not only are the origin and course of the trouble obscure, but the disease itself is frequently not recognized as a distinct and fatal malady, but is confounded with any weak or yellow condition of the tree. The name of the disease is unfortunate, since it leads people to regard yellowness as one of the first and indisputable symptoms of yellows, while, in fact, the disease may become well seated and may show its unmistakable symptoms in trees which are dark green and robust. It is for the purpose of enabling fruit growers to distinguish the true yellows from a multitude of other ailments that I have prepared the present report.

1. *Yellows "tips."*

NOTE.—Those who desire to make a more particular study of peach yellows, should consult the following publications of Dr. Erwin F. Smith, who is the recognized authority upon the subject:

Peach Yellows: A Preliminary Report. Bull. 9, Div. of Botany, Dept. Agric. 1888.

Additional Evidence on the Communicability of Peach Yellows and Peach Rosette. Bull. 1, Div. Veg. Pathology, Dept. Agric. 1891.

The Chemistry of Peach Yellows. I and II. Proc. Amer. Pomol. Soc. 1889 and 1891.

Peach Yellows. Report of State Hort. Assoc. Penn., 1893.

Experiments with Fertilizers for the Prevention and Cure of Peach Yellows. Bull. 4, Div. Veg. Pathology, Dept. Agric. 1893.

Peach Yellows and Peach Rosette. Farmers' Bull. 17, Dept. Agric. 1894.

It should first be said that the yellows is generally spread throughout the state. I have made a careful study of the peach industry of western New York during the present season, and I have run upon the yellows in almost every region which I have visited. It is particularly bad in Niagara county, which is the leading peach section of the state. It also occurs along the cen-



2. *Healthy terminal shoot.*

tral lakes, in the Hudson River valley, and, no doubt, wherever peaches are grown to any extent. Yet the disease is not also so serious in certain regions as people have supposed it to be. I have visited orchards which were said to be dying with yellows, and have found only borers and that sublime neglect which characterizes so many peach or-

chards of the state. Orchards which are never cultivated or pruned or fertilized, soon become sad-looking objects, making little growth and that of a feeble and yellow sort, and the borers hold unmolested carnival. In such cases, the first remedial treatment must be applied to the owner, for unprofitable or diseased orchards cannot cure themselves.

Fruit growers should know that peach yellows is a distinct disease, with characteristic symptoms, that it attacks the very best and strongest trees of the orchards as well as the weak ones, and that its end is always fatal. I have sometimes thought that the most vigorous trees are most liable to attack. It is certain that orchards in otherwise prime

condition may be completely swept away with the yellows.

The most lamentable circumstance connected with the yellows in this state is the legal complication which arose in Niagara County* in 1889, when an attempt was first made to enforce the

* Annals of Hort. 1889, 70.

law which demands that yellows shall be eradicated. Commissioners were duly appointed and they proceeded with their duty of examining orchards and marking diseased trees. There was little general or popular knowledge of the disease, and the commissioners consequently met with opposition. It was charged that they marked trees which were not diseased. Whether this is true or not, it transpired that a certain peach grower refused to cut the trees which the commissioners had designated. Under the law, the officers cut the trees, but the owner refused to pay costs, and the people brought suit against him for misdemeanor. The trial was long and stubbornly fought. The trees which had been cut were destroyed, and there was therefore no evidence to prove that the trees in question had had the yellows. Much testimony of a general nature was admitted by the court as a matter of general interest and education, but the question which went to the jury was the specific one concerning the defendant's trees. The jury disagreed, and the defendant was acquitted. The result was regarded as a great victory by those who opposed the operation of the law; and it has had the effect of discouraging further efforts towards its enforcement in that county. The outcome has been most disastrous. The yellows is now widespread throughout the region which is naturally the best peach section of western New York, and the dying and neglected orchards of careless peach growers are a constant menace to the peach industry. It will never be known, beyond the parties immediately concerned, whether the trees over which the suit occurred had the yellows; but I have this year visited the neighborhood which was the scene of the conflict and I found orchards ruined by the disease. Any law is impotent unless it is sustained and enforced by public sentiment. Every farmer should understand that peach yellows is a fatal and communicable disease, and that it is, therefore, amenable to control by the police powers of the commonwealth. Like pleuro-pneumonia and tuberculosis, it is a public nuisance.

When the yellows attacks a bearing tree, the first sign of its presence is usually in the fruit. The one unmistakable symptom in the fruit is the presence of bright red spots which may be likened to measles blotches, and the flesh is also more or less marked

by red spots and streaks which often run through to the pit. When the attack is slight, these red streaks in the flesh may be faint or even almost absent, but the external spots are characteristic. The illustration (Fig. 3) shows a diseased peach. In addition to these marks upon the peach, the fruit generally ripens prematurely, although I have seen cases in which the spots were



3. *Yellows peach.*

present upon fruit ripening in its normal season. On the other hand, yellows peaches sometimes ripen six weeks in advance of their season, particularly after the disease has run a year or two. Mere prematureness is not an indication of yellows. I have repeatedly been shown trees, during the past season, which were said to have yellows because the fruit ripened prematurely, but which were suffering only from borers, neglect or drouth. These peaches lacked entirely the bright red spots of the yellows. Yellows peaches are usually poor in quality, particularly in sweetness; yet when the attack is recent and the fruit is not markedly premature, the quality may not seriously suffer. In the second year of the visible attack, however, the quality of the fruit is perceptibly low.

Yellows generally appears at first upon a part of the tree only. Sometimes only one or two peaches may show any indications of the disease, and the tree may appear to be perfectly healthy.

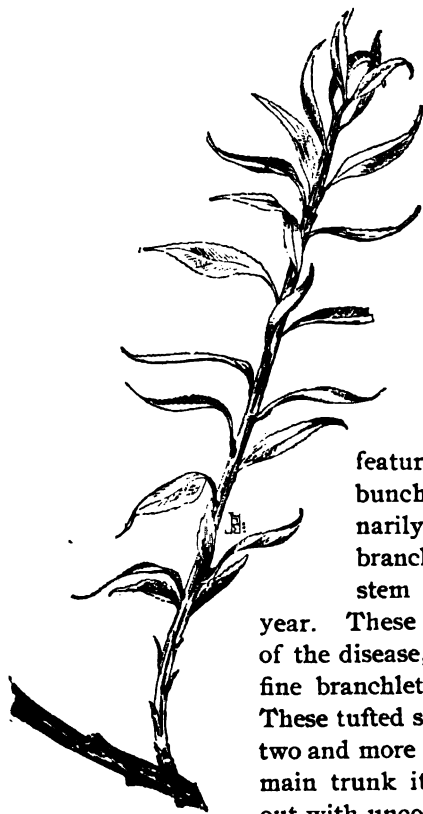
Whether the branch upon which these peaches are borne is removed or not, the disease will be found the following year to have spread, involving more branches and possibly the entire tree.

The second characteristic symptom of yellows—or the first in trees not in fruit—is the appearing of short, yellowish, unbranched shoots or “tips” upon or near the ends of the healthy branches. These sometimes appear upon the ends of lusty watersprouts, and in such cases I have seen them well developed even when the fruit showed no signs of disease. The tail-piece (page 408) is such a watersprout tip. These little shoots spring from buds of the season, which under normal conditions, would not have pushed into growth until the following spring. These shoots may appear as early as July or even June, but in the early stages of the disease they are usually not seen until late summer or fall. In this state, I see them first, as a rule, in September. When they appear at this date, they rarely grow more than three or four inches long. The leaves upon these yellows “tips” are small and narrow, yellowish, and they usually stand out stiffly at nearly right angles to the stem, contrasting strongly with the drooping healthy leaves below them. The tail-piece, on page 408, shows a yellows tip of Crawford, photographed late in September. Sometimes several of the uppermost buds upon a twig will start out into this short stiff tip-like growth. This feature is shown in Fig. 1. Contrast this shoot with the healthy twig, taken from the same tree, shown in figure 2. These tips sometimes appear late in fall after most of the leaves have fallen. The winter buds simply expand their sickly leaves and the stem may make no growth. Fig. 4 shows such tip, appearing late in October. Occasionally



4. Yellows “tip”
appearing late
in October.

one may see these tips expanding prematurely in earliest spring. Frequently, in this state, these tips are so little pronounced, even upon trees badly diseased, that they are likely to pass unnoticed ; and in such cases one must rely very largely upon the fruit for a diagnosis of the disease. In rare instances, the blossom buds upon diseased shoots may expand in the fall.



5. *Yellows shoot.*

The third symptom of yellows is the appearing of abnormal shoots along the larger branches or even upon the trunks. These yellows shoots generally appear earlier in the season than the tips, and may make considerable growth. They are marked by short and narrow leaves which stand at nearly right angles to the stem, as seen in Fig. 5. They rarely grow more than a foot in length in this state. But the most striking form of this third

feature of yellows symptoms, is the bunchy growth shown in Fig. 6. Ordinarily a healthy peach shoot does not branch as it grows, but makes a straight stem one year, and branches the next year. These yellows shoots, in confirmed cases of the disease, may branch into several or many fine branchlets the very year in which they start. These tufted shoots may spring from old branches two and more inches in diameter, or even from the main trunk itself (Fig. 6). They often spring out with uncommon luxuriance from the stumps of trees which have been cut with yellows. These bunchy growths rarely appear before the third year of the disease in this state, and in the great majority of cases of yellows which I have seen in New York they are wholly absent, even in the final stages. They appear to be less abundant in dry years. It is the first two symptoms—the red-spotted fruit and the



6. *Yellows tuft*— $\frac{1}{2}$ nat. size.

"tips"—which must generally be relied upon in this state for the diagnosis of the yellows; and even the tips, as I have said, may be so little developed as not to attract attention. The one unmistakable and invariable symptom of the peach yellows is in the fruit.

The fourth and final stage of the disease is that in which the entire tree assumes the narrow, yellow or reddish and rigid leaves, and in this condition the tree is not readily distinguished, by the novice, from trees which are much debilitated by borers or neglect. The length of time from the onset of the disease at which this final stage and the death of the tree occur, is not a fixed period. It is undoubtedly modified by many conditions. From the time when the first symptoms appear, it is not less than three years before death occurs, and it is oftener five or six years. But death is sure to come sooner or later, for there is no indisputable case on record of yellows having been cured.

There is abundant proof that yellows is communicable from tree to tree. Sooner or later, every peach tree in any community in which the disease appears, may be expected to die from it, unless rigorous measures are taken to keep it in check. The disease is so insidious and often so slow in its progress that it usually becomes thoroughly established in a community before it attracts attention, and peach growers generally procrastinate in applying restrictive measures. It is unknown how the yellows spreads, but it is not through the soil, for young trees may be set with safety where yellows trees have been removed. Neither is it always, if ever, conveyed from flower to flower, for trees which have not yet blossomed often contract the disease. It does not inhere in the roots, for trees grafted upon plum stocks contract it. There is every reason to believe, also, that it is not carried on pruning tools. The means by which the disease spreads will probably not be known until the cause of the trouble is ascertained. Respecting this cause, there has been distinct progress in eliminating almost every origin which has been ascribed for the disease. It is known that yellows is not due to conditions of soil or climate, to mechanical injuries, to over-bearing or starvation, to methods of propagating, pruning or cultivating, to insects or fungi, and Dr. Erwin F. Smith, of the national Department of Agriculture, who

is the recognized authority upon the disease, now declares that "it is almost certainly not a bacterial disease." Dr. Smith thinks that the disease is "nearest allied to that phenomenon in plants known as variegation." It has been long known that most variegation is an abnormal state or condition and that it can sometimes be communicated to normal plants by means of budding; but it is difficult to conceive of any means by which such condition can become contagious without the presence of germs.

But there is every reason to expect that when the cause of the yellows shall have been discovered, the treatment will remain the same as now,—extermination of the affected trees. This seems to follow, from the fact that when the first symptoms of yellows are discovered upon any branch, the entire tree is diseased. Numerous critical experiments have been made to determine this fact, by cutting off the diseased limb. In every case the remainder of the tree has shown yellows, usually the following year, but sometimes not until the second year. And these results are exactly in line with the experience of all peach growers who have had to deal with yellows. It will also be necessary to exercise the same caution in the choice of buds for propagation, for it is known that a bud from a yellows tree—even from that part of a tree not yet visibly affected—will make a yellows tree and will communicate the disease to the stock. Premature yellows peaches rarely have good seeds, but the pits from the apparently healthy portions of diseased trees may be expected to convey the disease to the offspring.

So far as known, peach yellows, like pear blight and plum knot, is a purely American disease, and has not been introduced into other countries. It is generally distributed in peach sections east of the Mississippi river and north of North Carolina and Tennessee. It first attracted attention about a hundred years ago in the neighborhood of Philadelphia, whence it appears to have spread throughout the country. It was probably introduced into the peach region of southwestern Michigan—where it appeared nearly thirty years ago—by diseased eastern stock. As near as I can learn, it appeared in Niagara county, New York, about twenty years ago. The disease seems to prefer the peach, but it is known to attack the nectarine, almond, apricot and Japanese plums.

The only check for the spread of the yellows is extermination of the affected trees, and I doubt if a better method will ever be discovered. There is much difference of opinion as to when and how the trees should be removed. If but a single branch is affected and the disease shows only in the fruit, it is considered to be safe to burn the diseased branch and fruit at once, but to allow the remainder of the tree to ripen its crop. As soon as this crop is off, pull up and burn the tree, root and branch. If the disease appears upon a tree not in fruit—even if upon but a single branch of it—I should forthwith, as soon as the disease was discovered, pull out the tree and burn it. There is a tendency in this state to allow the trees to stand until fall work is done or until some other convenient season shall arrive; but growers who practice such methods are not long troubled with peach orchards.

This method of immediate extermination has been proved time and again to be completely effective in holding the disease at bay. The experience of the Michigan peach growers is often cited, and it is undoubtedly the best illustration extant of the effectiveness of timely and coöperative effort. The oldest commercial peach region of Michigan is that lying in Berrien county, in the southwestern corner of the state. Here the yellows first appeared. At that time, the disease was little understood, and growers temporized with it, and tried to cure it. As a result, the entire peach industry was wiped out, and small fruits, grapes, and truck-gardening took its place. Lying twenty-five miles north of this St. Joseph region and then separated from it by several miles of wild country, is the South Haven region. In this second region the disease finally appeared and destroyed a number of orchards, but the people, profiting by the disastrous experience of their neighbors upon the south, soon began a vigorous war of extermination against it. The local pomological society united the leading peach growers in the crusade, and the state legislature was prevailed upon to pass a law providing for the legal exercise of police powers upon the part of townships. This was probably the first American law aimed at a disease of plants, and from it have sprung the perfected laws of recent years relating to yellows, black-knot and other diseases and insect pests. There were some growers of influence who resisted the law, but upon the whole the

community was united in the one determination to check-mate the yellows. For a time the disease seemed to over-ride all opposition, but it was finally checked, and it has not seriously interfered with the peach industry for the last dozen years. It is still present, however, and in certain seasons it breaks out with renewed vigor, but these recurrences are as vigorously met by the growers, and the disease again subsides. These years of renewed activity of the yellows are apt to follow years of comparative immunity, largely because of the less careful scrutiny by the yellows officers in the years of freedom from the disease. This determined fight against a common enemy has knit the peach-growing community together and has developed a local pride which is entirely absent in the peach sections of New York state. Public sentiment demands that no yellows peaches shall be shipped. A sign hangs in the warehouse at the port with this legend :

" All peaches left here infected with yellows will be destroyed and the owner prosecuted."

This sentiment is unknown to the New York peach growers, as a body. Everywhere I see yellows peaches on sale. These peaches are not injurious to health, so far as known, but they are inferior in quality, and the Michigan people have learned that the sale of them hurts their reputation and market. But the New York growers, as a rule, have not yet got beyond the point of asking if the diseased peaches are unwholesome, and have not risen to the plane of demanding that only good fruit, like pure milk, shall be allowed to make their reputation upon the market. And the clause of the law forbidding the sale of yellows peaches is practically a dead letter.

The success of the Michigan growers in stemming the invasion of yellows has revived confidence at St. Joseph, and that region is again growing peaches with its earlier eminent success. I do not expect equal success in eradicating yellows in this state, from the fact that the peach industry is nowhere extensive enough to make it the one absorbing interest of the community. As soon as it becomes the chief occupation of any region, the people will combine in self-interest to hold it in check. Yet the individual grower, if affected orchards do not adjoin his own, can keep the yellows at bay with a loss of only a few trees each year. There

are such growers in Niagara county and other parts of the state, and their success should reassure all those who despair at the inroads of the yellows. But it must be remembered that the most painstaking vigilance is required to keep orchards healthy, and the best remedy for the evil will be found in the rigid enforcement of the law. No amount of arguing will stop the yellows. Fire is the only recourse.

Most of the laws aimed against peach yellows have serious defects. The most glaring of these is the fact that the owner of the trees has no appeal from the decision of the commissioners who are appointed to examine the orchards. There is always danger that incompetent or careless men may be appointed to the commissionerships, whose rulings may not be acceptable even to the best disposed citizens. The disease is so obscure that only the most careful and judicious men should be selected to diagnose it, and, even at the best, there are men in almost every community who object to the destruction of their trees. Lack of confidence in the commissioners has been the most serious obstacle to the execution of the New York law, and it was at the bottom of the suit which occurred in Niagara county in 1889. There is a feeling, also, that the work of the commissioners in cutting trees is the invasion of a man's property without due process of law. All this is remedied in the Connecticut law—which is the best of all yellows laws,—for the owner may appeal from the findings of the commissioner to the State board of agriculture, which “shall appoint a committee of three experts, which committee shall not include the person who, acting as commissioner or deputy, ordered such tree or fruit destroyed, and the decision of such committee shall be final.”

Another difficulty with the laws is the danger that political considerations will prevail in the appointment of the commissioners. This danger is imminent whenever the commissioners are appointed by any officer or board which is itself a political appointment or creation. The difficulty can be averted only when the commissioners are created by a non-political board or office, as in Connecticut.

Other hindrances against the efficient operation of yellows laws are the inadequate pay given the commissioners—often rendering

the appointment of thoroughly competent men impossible—and the lack of any general office or officer who shall keep records of the spread and control of the disease. This latter omission is serious, from the fact that it is only by a study of careful statistics extending over a series of years that the progress of the disease can be accurately known and the effectiveness of remedial laws adequately measured. This important statistical feature has been embodied in the Connecticut law, and the yellows commissioner reports that in the year 1893 official examinations were made of 283,782 trees, of which 28,647 were condemned.

The full text of the Connecticut yellows law is as follows :

SECTION 1. The State Board of Agriculture shall, within thirty days from the passage of this act, appoint a commissioner on peach yellows, to hold office during the pleasure of said board. Said commissioner may, with the approval of said board and under the provisions of this act, adopt and carry out such plans as may be deemed necessary for the eradication of the disease, common to peach trees, known as peach yellows.

SEC. 2. At all joint meetings of said board and said commissioner, for the purpose of conference, the commissioner shall receive pay from the board for his expenses only. Said commissioner may, with the approval of said board, appoint one or more deputies in each county ; and when employed in the performance of duties imposed by this act, said commissioner and his deputies shall receive from the state, upon presentation to the comptroller, of bills duly sworn to, audited by the auditing committee of the board of agriculture, and approved by the Governor, five dollars per day and their expenses.

SEC. 3. Any peach, almond, apricot, or nectarine tree diseased by the yellows, and all fruit from any such diseased tree, is hereby declared a public nuisance, and it shall be the duty of said commissioner or any deputy, under such regulations as the State board of agriculture may adopt or approve of, to order such trees or such fruit destroyed, and upon the failure of the owner to obey such order, to destroy such trees or fruit, and no damage shall be paid to such owner on account of such destruction.

SEC. 4. Any person may, when ordered to destroy any tree or fruit condemned by the said commissioner or deputy, appeal to the State board of agriculture, and said board shall appoint a committee of three experts, which committee shall not include the person who, acting as commissioner or deputy, ordered such tree or fruit destroyed, and the decision of such committee shall be final.

SEC. 5. Any person who shall, while such an appeal is pending, sell any tree from a nursery where there are found to be diseased trees, or any fruit from such tree; or who shall, without such appeal, or after such final decision, refuse to destroy such tree or fruit, shall be fined not less than one hundred or more than five hundred dollars.

SEC. 6. Any person that shall knowingly buy, for the purpose of selling, or shall sell or offer for sale, any fruit from such diseased trees, shall be fined not less than ten nor more than one hundred dollars.

SEC. 7. For the purpose of investigation or for the purpose of destroying trees or fruit known to be diseased, the said commissioners and his deputies may enter any premises; and any person who shall prevent or attempt to prevent such entry shall be punished by a fine of not less than ten or more than one hundred dollars, or imprisoned in a common jail not less than ten nor more than sixty days, or both.

SEC. 8. Prosecutions for violation of this act may be brought before justices of the peace, or any city, borough, town police, or common pleas court having criminal jurisdiction, by any prosecuting officer, or by the commissioner on peach yellows, or any of his deputies, and for such purpose said commissioner and his deputies shall have all the power of grand jurors.

SEC. 9. This act shall take effect upon its passage.

YELLOW S BREVITIES.

Yellows is a distinct disease. It attacks peach trees of all ages and in all conditions of vigor, seeming to have a preference for those which are thrifty. It is incurable, and its termination is always fatal.

The disease sometimes attacks the almond, apricot, and Japanese plum.

Yellows has been recognized for about a century. It is peculiar to North America, and is generally distributed north of the Carolinas and east of the Mississippi.

It is communicable from tree to tree. The means of communication is unknown, but it is not spread through the soil, it does not originate in the roots, it is evidently not conveyed from flower to flower, and it is probably not transferred by means of pruning tools.

The cause of the disease is wholly unknown. Almost every ascribed cause has been disproved upon careful investigation.

It has no uniform preference for varieties, soils, climate, nor methods of propagation or cultivation.

No fertilization of the soil will cure the disease or check its spread.

The one unmistakable symptom of yellows is the red-spotted character of the fruit. The flesh is commonly marked by red lines or splashes beneath the spots. These peaches generally ripen prematurely, and in the second year they are usually smaller and often more fuzzy than the normal fruit. The second symptom to appear—or the first in trees not in fruit—is the “tip” growth. This is a short growth starting from the upper or terminal buds, usually late in the season, and is characterized by narrow stiff yellowish small leaves which stand at nearly right angles to the shoot. Sometimes these tips appear late in autumn, after the leaves have fallen, or in spring before normal growth begins. They are often first seen upon the ends of watersprouts. This “tip” growth is sometimes little pronounced, and then only a practiced eye will detect it.

The third mark of the disease is the pushing out of slender stiff-leaved yellowish shoots from the body of the tree or the sides of the large limbs. In pronounced cases, or when the tree is about to die, these shoots may branch into close bunchy tufts. These symptoms are frequently wholly absent in this state throughout the entire course of the disease.

In its final stage, the disease is marked by small and slender growth of all new wood, small, narrow, yellow or reddish foliage, and occasionally by a great profusion of slender and branchy growths in the center of the tree.

As a rule, yellows trees die in five or six years from the first visible attack.

The yellow and stunted condition following neglect or the work of borers—both of the common borer and the pin-hole borer—is often mistaken for yellows.

Extirpation of all affected trees—root and branch—is the only method of keeping the disease at bay. This work should be

prosecuted vigorously and systematically and with the full support of the entire community.

Trees may be set in the very places from which yellows trees have just been removed, with entire safety.

The disease is readily communicated to nursery stock by affected buds, even by buds from those branches of affected trees which do not yet show any signs of the yellows.

Pits from affected trees—when viable—may be expected to propagate the disease.

L. H. BAILEY.



Yellows "tip" on a watersprout.

D 30.617

Y7
C82b

JAN 18 1909

Bulletin 76.

November, 1894.

Cornell University Agricultural Experiment Station.

HORTICULTURAL DIVISION.

SOME

GRAPE TROUBLES

OF WESTERN NEW YORK.



By E. G. LODGMAN.

PUBLISHED BY THE UNIVERSITY,
ITHACA, N. Y.
1894.

ORGANIZATION.

BOARD OF CONTROL:

THE TRUSTEES OF THE UNIVERSITY.

STATION COUNCIL.

President, JACOB GOULD SCHURMAN.

Hon. A. D. WHITE,	-	-	-	-	Trustee of the University.
Hon. JOHN B. DUTCHER,	-	-	-	-	President State Agricultural Society.
Professor I. P. ROBERTS,	-	-	-	-	Agriculture.
Professor G. C. CALDWELL,	-	-	-	-	Chemistry.
Professor JAMES LAW,	-	-	-	-	Veterinary Science.
Professor A. N. PRENTISS,	-	-	-	-	Botany.
Professor J. H. COMSTOCK,	-	-	-	-	Entomology.
Professor L. H. BAILEY,	-	-	-	-	Horticulture.
Professor H. H. WING,	-	-	-	-	Dairy Husbandry.
Professor G. F. ATKINSON,	-	-	-	-	Cryptogamic Botany.

OFFICERS OF THE STATION.

I. P. ROBERTS,	-	-	-	-	-	Director.
E. L. WILLIAMS,	-	-	-	-	-	Treasurer.
H. W. SMITH,	-	-	-	-	-	Clerk.

ASSISTANTS.

M. V. SLINGERLAND,	-	-	-	-	-	Entomology.
GEO. C. WATSON,	-	-	-	-	-	Agriculture.
G. W. CAVANAUGH,	-	-	-	-	-	Chemistry.
E. G. LODEMAN,	-	-	-	-	-	Horticulture.
MICHAEL BARKER,	-	-	-	-	-	Horticulture.

Office of the Director, 20 Morrill Hall.

Those desiring this Bulletin sent to friends will please send us the names of the parties.

BULLETINS OF 1894.

62. The Japanese Plums in North America.
63. Co-operative Test of Sugar Beets.
64. On Certain Grass-Eating Insects.
65. Tuberculosis in Relation to Animal Industry and Public Health.
66. Test of Cream Separators.
67. Some Recent Chinese Vegetables.
68. The Cultivated Poplars.
69. Hints on the Planting of Orchards.
70. The Native Dwarf Cherries.
71. Apricot Growing in Western New York.
72. The Cultivation of Orchards.
73. Leaf Curl and Plum Pockets.
74. Impressions of the Peach Industry in Western New York.
75. Peach Yellows.
76. Some Grape Troubles of Western New York.

CORNELL UNIVERSITY, ITHACA, N. Y., Nov. 1, 1894.
THE HONORABLE COMMISSIONER OF AGRICULTURE, ALBANY.

Sir: The following account of some of the difficulties in the way of grape growers in the Fifth Judicial Department of New York, is submitted as a bulletin to be published under the provisions of Section 87, Chapter 675, of the laws of 1894.

The trouble known as "rattles" has been very serious the past season, particularly in the Chautauqua region. We have made a thorough study of it in the field, and the following paper is believed to contain the best information obtainable concerning it. Definite and perhaps prolonged experiment upon an extended base is needed, however, to discover the exact cause and to suggest specific remedies.

Grape growing is one of the leading industries of the state, and its area is increasing. The extent and distribution of the acreage in western New York are approximately as follows:

Chautauqua region,	-	-	-	-	-	26,000	acres.
Canandaigua	"	-	-	-	-	5,000	"
Keuka	"	-	-	-	-	10,000	"
Seneca	"	-	-	-	-	6,000	"
Cayuga	"	-	-	-	-	3,500	"
Scattering, -	-	-	-	-	-	7,500	"
Total, -	-	-	-	-	-	58,000	acres.

L. H. BAILEY.

SOME GRAPE TROUBLES OF WESTERN NEW YORK, 1894.

SYNOPSIS.

PART I. IN CHAUTAUQUA COUNTY (pages 413 to 443).

A. Shelling or Rattling, page 413.

Similar European Diseases :

Apoplexie or Folletage, page 420.

Rougeot; page 421.

Ascribed causes of shelling, page 421.

Group I. Injuries caused by parasites, page 423.

Group II. Improper conditions of the vine, page 425.

Group III. Conditions of the soil, page 427.

Group IV. Conditions of the atmosphere, page 435.

Remedies, page 435.

Opinions of Growers, page 436.

B. Powdery Mildew, page 441.

C. Anthracnose, page 442.

PART II. IN CENTRAL NEW YORK (pages 444 to 449).

D. Black-rot, page 444.

E. Brown-rot, Gray-rot, page 446.

F. Ripe-rot, page 448.

PART III. MACHINERY FOR SPRAYING, FORMULAS (pages 450 to 452).

Summary, page 452.

PART I—IN CHAUTAUQUA COUNTY.

A. SHELLING OR RATTLING (pages 413 to 440).

Many grape growers of Chautauqua county have this year lost a considerable portion of their grapes on account of the berries dropping to the ground before they were fully mature. This condition is commonly known as the "shelling" or the "rattling" of the grapes. Its unusual prevalence and the severity of the attacks in some vineyards have caused the vineyardists much uneasiness regarding the losses caused and the possible extent to which the trouble may affect the vines in the future. During the past fall it has appeared more or less seriously throughout the region of the Chautauqua grape belt, and some portions of central New York have not entirely escaped its presence.

The trouble is not a new one. familiar to observing vineyard-twent-five years, and it is probable that it has existed even longer. It is the severity of the attack which has this fall affected the vines that has made the Chautauqua vineyardists in particular anxious regarding the cause of the trouble and the remedies which may be applied to prevent its reappearance.

Description.—The shelling of grapes takes place in the following manner. As the season of ripening approaches, certain berries of the affected clusters fall to the ground on account of the inability of the main fibres and other connecting tissue of the fruit-stems to sustain their weight. Figure 1 represents a normal separation of the berry from the stem as commonly pulled off; Fig. 2 shows the manner in which this separation takes place in the case of shelling. The end of the stem is even, as if cut with a knife.



FIG. 1.—Normal separation of berry from the stem.

The portions of the cluster first affected are, so far as my observations go, invariably either the lower extremity of the cluster as it hangs from the cane, or, in the case of heavily shouldered clusters, the outer extremity of the stem forming the shoulder. The shelling may begin at both points at about the



FIG. 2.—*Abnormal separation of berry from stem, as it occurs in shelling.*

same time, but it generally makes its appearance first at the lower end of the bunch. Sometimes only one or two berries may fall, but in other cases the drying and shriveling of the stem gradually extends upward, the affected portion being plainly marked by the absence of the berries, as shown in Fig. 2. It often

occurs that not a berry remains hanging upon the bunch. In such cases the ground below the bearing portions of the vine is literally covered with the fallen fruit, and from a distance it presents, in the case of Concord, a strong blue color.

Some clusters upon a vine seem to be more free from shelling than others upon the same plant. This seems to be due in many cases to its location upon the cane, but there are so many exceptions that no definite rule can be laid down. In general, however, it may be said that of the clusters found upon a certain cane the one which is situated farthest from the main stem of the plant is most seriously affected. There are many exceptions to this statement, but the majority of cases which I have seen confirm it.

Another peculiarity which may sometimes be seen, although cases of it are very rare, is the shelling of berries upon only one portion of the vine, as for instance those borne upon the canes which spring from an arm, the difficulty thus affecting only one-half of the plant. One case was noticed in which the clusters found upon one cane were the only ones which suffered, amongst all those borne by the vine. The fact that such cases are seldom found would tend to show that they represent a singular phase of the disease, and are produced by some local cause, perhaps varying in the different cases. They cannot be considered as typical of the common form in which it appears.

It very commonly occurs that plants in certain portions of a vineyard shell, while the large majority of them do not. The line is sometimes so sharply drawn that the affected plant may be entirely surrounded by healthy vines; and it is not uncommon to find a healthy vine in the midst of those which shell. Occasionally the plants in a row are quite different as regards the amount of fruit which is lost, some retaining all, while others lose fully 75 per cent. Such vineyards, however, do not represent the large majority. In these, the shelling is more or less uniform throughout the vineyard, and only in exceptional cases does the loss reach 50 per cent. of the crop. The total loss in the "belt" will probably not exceed 5 per cent. of the entire yield this year.

The taste of shelled grapes differs decidedly from that of those remaining upon the upper portion of affected clusters and still more from that of berries which are borne upon vines in which no

shelling takes place. This difference is very noticeable in Concord. Grapes of this variety, when grown under favorable conditions, are sweet and very agreeable to the taste, on account of a flavor which is peculiar to the variety. Shelled grapes are extremely insipid, and are unpalatable not only from a want of taste but also from a certain disagreeable flavor which, though seldom strong, is still perceptible. Berries which remain upon shelly vines lack flavor, but otherwise they do not appear to possess any particularly disagreeable qualities.*

Vines which have shelly grapes are almost invariably affected by what is commonly called the leaf-blight. This generally appears late in July or during August. This year it came on late in August and during the first week of September, which is about the time that the grapes began to fall from the vines. The blight causes the death of the leaf tissues, but all the leaves do not appear to be equally affected. The younger growths are the ones which suffer most. The leaves at the outer extremities of the shoots first show a yellow discoloration which follows more or less continuously the outer margin. Soon this yellow portion dies and turns brown. This causes the leaf to curl at the edges as shown in Fig. 3. As the disease progresses, older leaves are affected and in severe cases the amount of brown in the foliage is noticeable from a considerable distance. Many of the vineyards showed this discoloration so plainly that it was not necessary to enter them to be assured that the grapes were shelling.

The shelling of grapes is not invariably accompanied by any decided discoloration of foliage, nor is the browning of the leaf tissue a certain indication of shelling; but the few exceptional cases in which the one takes place without the other scarcely have sufficient weight to throw any serious doubt upon the probable relation existing between the two. I have been assured by several

* Chemical analyses of shelling grapes are now being made with the hope that some light may be thrown upon the subject by the berries themselves. In addition to this, fertilizer experiments have been planned and several are now under way to determine the kinds and amounts of fertilizers that are necessary to the proper maturing of a crop of grapes, and also to find what amount of fruit can regularly and profitably be borne by a vine without injury to it. The results of these investigations should be published as soon as definite statements can be made.

growers that in years past they have been able to tell during the summer which vineyards would shell during the fall, basing their

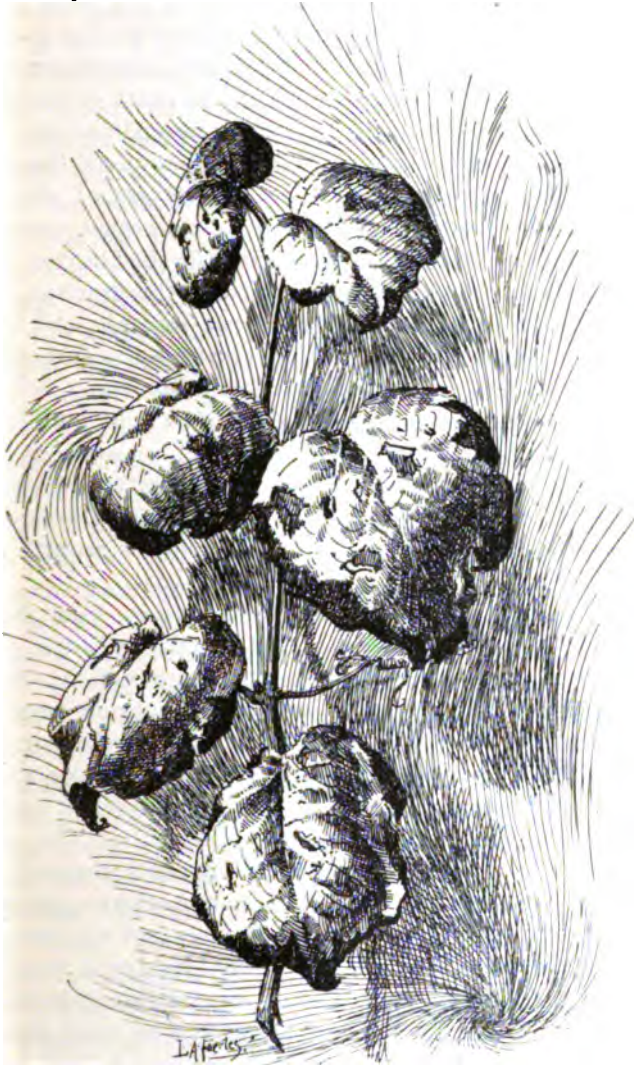


FIG. 3.—*Diseased foliage upon a shelling vine.*

conclusions entirely on the fact that the foliage began to assume this brown tinge. The leaves are not often entirely destroyed,

for they remain upon the vines until fall, the green portions probably still acting in a normal manner.

A dark discoloration often found between the main veins of the leaves may be attributed to the same cause as that producing the death of the edges. These dark portions, (sometimes they are nearly black) do not necessarily indicate the death of such places for the thickness of the leaf is apparently normal and the marked curling of the leaf is wanting. In these respects the trouble seems to differ from the browning and drying of the leaf as mentioned above, and it may be due to some other cause. Inquiries during one season were insufficient for the drawing of more definite conclusions regarding the cause of this trouble. Below (p. 420) are also given descriptions of two diseases which attack vineyards in France and it is possible, although not probable, that this one is of a similar nature to the European ones.

In 1890 the grape growers of western New York suffered from a disease which caused the grapes to shell in some cases very severely. D. G. Fairchild, assistant in this section of Vegetable Pathology in the U. S. Department of Agriculture, was directed to investigate this trouble and an abstract of his report* is here given.

Definite reports of the trouble were received from Niagara, Wayne, Cayuga, Seneca, Steuben and Ontario counties, but it is probable that grapes were affected in other parts of the state.

"Small irregular bunches of a dark color appear between the veins, these enlarge rapidly, darken to a dull purplish or reddish brown and coalesce so as to fill up the space between the veins which remain green or yellow. These changes occur so rapidly that the foliage seems to change color suddenly. The contrast between the green or light yellow veins and dark purplish brown of the intervening tissues gives a peculiar streaked appearance to the leaves. In the most serious cases they curl up, become dry and brittle, and finally drop from the vine, leaving it nearly bare.

"The berries borne upon diseased vines, almost without exception, have a flat, insipid, and often intensely sour taste, due to the fact that they are only partially ripened. When the attack is severe the berries drop off, and the ground beneath a diseased vine is often

* Journal of Mycology, vi. 96. Annals Hort. 1890, 74.

seen to be covered with half ripe grapes. The berry is found to part from its pedicel taking with it the fibres which enter the interior of the pulp and are normally withdrawn from it when the berry is pulled off. After the crop has been harvested, also, the bunches are found to 'shell' badly, ruining them for market.

"The roots of diseased vines, when carefully examined, fail to show a healthy growth of young feeding rootlets. When the roots of healthy and unhealthy vines are compared, although as is to be expected late in the season (October 20-25) the fibrils have many of them dropped from all vines, the difference in favor of the healthy vines points quite plainly to the fact that root absorption was stopped earlier where the disease is present. The early stoppage of the action of the rootlets may account for the peculiar coloring of the leaves and failure of the canes to mature their wood. * * * A careful microscopic examination of all parts of the diseased vine has revealed absolutely nothing of the nature of a parasitic fungus which could in any way be connected with the malady. Leaves, canes and roots seem perfectly free from any form of parasitic plant or animal. * * * In general it may be said that the worst attacks of the disease occur upon cold, heavy soil containing a large percentage of clay and rich in nitrogenous matter. * * * So far as the investigation goes there seems to be no connection whatever between the fertilizer used and the trouble, diseased plants being found upon land unmanured, heavily manured, fertilized with phosphates, wood ashes, and bone dust."

The disease described by Fairchild is undoubtedly identical with the rattling or shelling of grapes as it occurred this fall, although the appearance upon the leaves has not been similar to that observed the past season. From somewhat incomplete meteorological data, I find that in general the season of 1890 resembled that of 1894. The spring was very wet, the summer inclined to be dry, and the months of September and October very wet.

In this connection it may be well to mention two diseases which attack French vineyards. They are frequently spoken of in connection with the shelling of grapes, and to assist in clearing up the problem the two diseases are described. The causes of apoplexy and rougeot are apparently clear, and meteorological con-

ditions may be held responsible for their appearance. When we come to the origin of grape shelling, the same causes do not appear, and meteorological influences seem to assume but a secondary position.

Apoplexie, or Folletage.*—These are the names applied to a phenomenon which generally appears in July or August in vineyards, especially in those growing on deep and rich soils, which previously showed no signs of disease. Upon isolated plants, or sometimes upon entire portions of a vineyard, there suddenly appear leaves which have lost their lustre, and their natural turgescence; in consequence they wilt and perish. The shoots dry from above downward, and soon the entire plant dies. The trouble however, is not always so severe as to cause the death of the plant. One portion only of the plant may be affected and the remainder be apparently healthy. But the shock to the plant is always severe, and generally the effects of such an attack are beyond perfect repair. The explanation which Leclerc gives† is as follows: "The rainfall during the year has been very heavy and thus prevented the rapid heating of the soil and also caused the atmosphere to be saturated with the vapor of water. In addition, the skies of Touraine have been almost constantly overcast. The growth of the vines was made, one might almost say, in the shade, and under these circumstances the tissues of the plant have not acquired the powers of resistance which they would have had if the sun had shone oftener. The tissues were gorged with water; the evaporation from the plant was slow in consequence of the humid condition of the air. The experiments of Sachs show that transpiration (evaporation) increases as the temperature of the soil is raised. Consequently the passage of water through the roots and the wood must have been slow and a certain balance was established between it and the process of transpiration. Let us suppose, now, that suddenly the burning rays of the sun strike the well developed foliage of the vines. The air is warmed, dried more and more as the temperature increases, and with the increased heat and dryness of the air the evaporation of the plant becomes more energetic. Since the water lost from the leaves

* G. Foëx, Cours Complet de Viticulture, 1891, p. 466 *et seq.*

† Ibid. p. 467.

and green parts cannot be instantly replaced by the roots, on account of the rate of circulation already established; those parts wilt, and when they have dried to a certain point they perish." In conclusion, apoplexy may be said to be due to a disturbance of the equilibrium existing between the absorption of water by the roots and its evaporation from the leaves. No remedy is as yet known for the trouble. Thorough drainage may lessen its severity in some soils.

Rougeot appears, from the conditions which cause it and by its general nature, to be allied to apoplexy. Like the latter, it attacks vines in full growth, at the time of the first heated periods, and is most serious upon cool, deep soils. Thiébaud de Berneaud says* that the disease is produced "during summer, after a cold rain, a storm which causes a sudden fall of temperature, or a fog which is followed by warm southerly winds." Marès describes the disease as follows: "The leaves begin to change, shrivel and lose their suppleness. The parenchyma turns red while the veins remain green, which gives the foliage a very peculiar appearance. The berries wilt and the shoots remain yellow. If the trouble increases, the leaves dry entirely and the stems die partially, sometimes only one side being affected, the diseased portion extending from the extremity to the base of the shoot. Such shoots often start a later growth during the latter part of the season. Plants attacked by rougeot do not die, as in the case of apoplexy, but they are severely checked, and several years are necessary to a complete recovery." Drainage should be carefully attended to, and particular pains taken to prune short, or at least down to sound wood. In extreme cases the plant may be renewed by grafting low upon the trunk of the vine.

Ascribed Causes of the Shelling of Grapes.—The causes which lead to the shelling of grapes are very obscure. Although the trouble has existed a long time among the vineyards of Chautauqua county, there are still numberless theories advanced as to the influences which produce it. Nearly every grower has a theory regarding it, but many confess that the disease is a mystery, and that none of the theories advanced will properly explain its

*Ibid. p. 469, cited from *Nouveau Manuel complet du Vigneron Française*, p. 186.

appearance. The following are the more important of these possible causes :

1. Insects.
2. Fungi.
3. Blight of the foliage.
4. Stems shrivel before the berries mature.
5. Berries prematurely ripe.
6. Premature ripening of the wood.
7. Overbearing.
8. Too much wood and foliage.
9. Too rich land.
10. The kind of soil.
11. Too much cultivation.
12. Excessive drought.
13. Excess of moisture after drought.
14. A weak root system.
15. Want of barnyard manure.
16. Want of phosphoric acid.
17. Want of potash or of some other element.
18. Excessive heat.
19. South wind.
20. West wind.

Such a variety of opinions regarding the causes that produce the shelling of grapes should include some at least which offer the true solution of the problem. Before considering the list in detail, it may be convenient to divide these opinions into groups, basing the division upon the close relationship existing between many of them. They fall readily into four groups, as follows :

- I. Injuries caused by parasites : embracing Nos. 1-3.
- II. Improper condition of the vine : embracing Nos. 4-9.
- III. Condition of the soil : embracing Nos. 10-17.
- IV. Condition of the atmosphere : embracing Nos. 18-20.

The various opinions will be considered individually so that their real value may be properly estimated.

GROUP I.

Injuries caused by parasites.

1. *Insects*.—It is believed by many that much, if not all, of the shelling of grapes is due to the action of insects. This point was constantly kept in mind during the examination of vineyards, and both clusters and vines were searched for insects which might be supposed to cause the trouble. In not a single case, however, did I discover any pest to which could be attributed the shelling of the grapes, and this theory had to be abandoned from want of evidence. If the trouble is caused by an insect, it works "in ways that are dark and devious" and when found will prove to be very interesting.

2. *Fungi*.—A majority of the vineyards visited were found to be infested with powdery mildew (*Uncinula spiralis*). This was found growing abundantly upon the leaves and fruit-stems of some vines and traces of it could be found in almost every vineyard. This mildew appeared late and was not found upon any berries. It formed a white mealy coating upon the main stems of the clusters, but comparatively little was found upon the pedicels of the individual berries. Its presence upon the foliage could easily be detected by the silvery-gray appearance of certain portions of the upper side of the leaf, these areas being very plainly marked in those portions freely attacked. Almost the whole of this fungus rests upon the leaf, and only the suckers which are in search of nourishment enter into the leaf tissue. This permits the parasite to be rubbed off very easily and the only trace of its former existence upon the leaf is a darkening or blackening of the portion which was most thickly covered.

In severe cases this fungus will cause grapes to fall from the vines, for the following reason. Let us suppose that the stem of a cluster is thickly infested with the mildew. A great many suckers will be sent into the green portion of the stem and much nourishment will be taken away from the berries. Another effect will be to obstruct the free flow of sap and this will again cause the berries beyond the point of injury to be deprived of the materials which were originally intended for their use. "We sometimes find nearly full-grown berries completely overgrown with mycel-

ium of the *Uncinula* so that the brown specks above mentioned, [produced in the berries by the action of the suckers] if present at all, are completely hid from view. These berries eventually become dry and shrivelled, and finally drop off."*

If the shelling of grapes as it occurred this fall were entirely due to the presence of the powdery mildew, then the degree of shelling should be directly in proportion to the severity of the attack of the mildew. The vineyards, however, did not bear out this proposition. Vines in which scarcely a trace of mildew could be found, frequently lost a large amount of their fruit, and again many clusters were seen having their stems literally covered with the fungus, yet no berries fell to the ground. The frequency of such cases has led me to believe that the powdery mildew is not the principal cause of the shelling of grapes, although in certain cases it may have exerted an influence in this direction, and possibly some berries fell from this cause alone. The cause for the bulk of the shelling must be sought elsewhere.

3. *Blight of the foliage*.—By the term "blight" is meant the browning of the leaves as already fully described upon page 416. Affected portions have been examined under the microscope but no traces of insect or of fungous injury could be found. The manner in which the leaf succumbs indicates that the trouble is not local, but that something is wrong in the whole plant economy. Consequently it seems to be safe to say that the so-called blight is not a cause of the shelling of grapes, but it rather appears to be a condition resulting from the same causes which make the berries drop to the ground; in other words, the browning and dying of the edges of the leaves and of those portions situated farthest from the main vines is to the leaf what the dropping of the lower berries from a cluster is to that cluster. Neither is dependent upon the other, and both are the result of some common cause.

* Scribner's Report on the Fungous Diseases of the Grape Vine. U. S. Dept. of Agric. Bot. Div. Sec. of Veg. Path. Bull. II. p. 22.

GROUP II.

Improper conditions of the vine.

4. *Stems shrivel before the berries mature.*—From the peculiar manner in which the lower end of the stems of fruit clusters shrivel and dry, one would naturally be led to suppose that the green wood failed to ripen. This shrivelling of the stem necessarily cuts off the supply of nourishment from the fruit, which in consequence drops. But the true question now is, what is the cause of this shrivelling? When that is answered, we shall have the answer to the question regarding the cause of the shelling.

5. *Berries prematurely ripe.*—This is little more than a mere statement of the fact that when grapes are perfectly ripe they separate from the cluster in the same manner as do the shelled grapes. That this ripening is premature is evident, for the large majority of berries still remain upon the vines while the others are falling. This theory throws no light upon the cause of the trouble.

6. *Premature ripening of the wood.*—In case the wood of a grape vine ripened prematurely, it would undoubtedly exert an influence upon the fruit itself. The character of this influence would probably vary with the age of the berries. If a cane bearing clusters be broken during midsummer when the fruit is about one-half grown, the berries will not fall to the ground, but they will remain hanging upon the stems even after being perfectly dry and shrunken. Although such wood is not properly ripened, it resembles well ripened wood by not admitting of the free passage of nourishing elements. The same result is obtained when a certain portion of a cluster is girdled by anthracnose. If such accidents occur when the berries are fully grown or coloring, the effect may be different, for then there may be sufficient nourishment present to enable the berry to continue to ripen, although imperfectly, and to allow the natural separation of berry and stem to take place. But even if it is granted that the shelling of grapes is due to the premature ripening of wood we are still in search of the cause of this ripening.

7. *Overbearing.*—A vine overbears when it sets more fruit than it can ripen without interfering with the production of a sufficient

amount of healthy foliage and wood. Vines which have set too much fruit show it in the comparatively little amount of new growth, in the smaller size of the leaves and fruit, and in the slowness with which they ripen their fruit. There are, of course, many degrees of overbearing and appearances will not be identical in the different cases. In severe cases the berries grow slowly and color slowly, and they may remain unripe until very late in the season, or perhaps never ripen well. It has already been stated on page 425 that grapes must attain a certain degree of maturity before they part naturally from the stem. It is probable that in some severe cases of overbearing the berries never reach this point. I have seen, on Cayuga Lake, Catawbias which, during the season just passed, had only begun to color on October 5. Yet they did not shell. Other vines in the same vineyard, some having much better colored fruit, did lose a few berries. These vines appeared to be carrying too much fruit, still it was fairly well colored; similar cases were also seen in Keuka Lake vineyards.

The effects of overbearing are not limited to one season, but the plant may suffer for a year or two on account of the weak condition in which it was left at the close of the first, and it is not improbable that this weakened condition may be exhibited by the grapes shelling. Still, in visits paid to the vineyards of Chautauqua county the yield per acre seemed to have little connection with the degrees of shelling, and strong vigorous foliage was by no means a proof that the grapes were not shelling; in many cases it was quite the contrary as regards the character of the foliage. In fact, some growers have advanced the idea that the vigorous foliage was the cause of the trouble.

8. *Too much wood and foliage;*

9. *Too rich land.*—These two theories can properly be considered together as the last named is the cause of the other. Their origin probably lies in the fact that vines growing in strong black land, that which is commonly found in hollows and which is frequently called black walnut land, are particularly apt to shell, while vines growing on higher land hold their fruit. I have seen in the vineyards of Mr. E. H. Fay, Brocton, N. Y., rows which began to shell as soon as they dipped into this dark, loamy soil, yet just above no grapes fell. The land is undoubtedly rich, but is it rich

in the proper elements? Nitrogen is there in more than sufficient quantities, but other things than nitrogen are wanted for the perfecting of a grape crop, and it is very possible that some of those other elements may not be present in proper quantities to supply the demands of the larger amount of wood which has been made, as well as to ripen the fruit properly. In case there is not enough food the fruit will be the first to show the effects.

On higher land where the growth is not so rank, the demands of the ripening wood are not so great and the fruit is better cared for. Too much nitrogen, therefore, is detrimental to the profitable development of the grapes.

GROUP III.

Conditions of the soil.

10. *The kind of soil.*—That the shelling of grapes is worse as a rule upon some soils than upon others is a very common belief, and the subject is closely related to the two preceding. About Ripley, the soils which are supposed to produce shelling vines are the low rich lands, the higher ones being free. I found an exception to this rule in the vineyard of Mr. H. J. Lewis, and about Portland several cases could be mentioned in which the high land shelled as badly as the low. At Forestville it is a common saying that clay lands are free from the trouble, but there are many cases which contradict the statement. My observations have led me to the conclusion that the character of the land is not an indication of the degree to which the grapes will shell. This reservation should nevertheless be made: that lands which are rich in nitrogen, and which consequently make an unusually strong growth of wood and foliage, are strongly inclined to produce vines which shell, while lands making a normal amount of wood and healthy foliage are inclined to be free from the trouble.

11. *Too much cultivation.*—The effect of too much, or too late cultivation, is practically the same as that of feeding plants nitrogen. It cannot be denied that the amount of shelling found in poorly cultivated vineyards has on the whole been less than in those which have been well cultivated, other things being equal.

It is said that one grower boasts of harvesting from his vineyard two tons of hay and three tons of grapes per acre; yet his grapes did not shell. I have seen a case* in which two men owned adjoining vineyards which were growing on the same land and had had the same treatment in past years. During the past season one had not been cultivated and the other had been. The latter shelled considerably, the former practically none. Vineyards that were growing nearly in sod were almost invariably free from the trouble. Many vineyards that were not cultivated also shelled, but unquestionably the well cultivated vineyards suffered more than those which were not so thoroughly tilled. The explanation for this fact is probably the same as that which will clear up the shelling of grapes upon the soils rich in nitrogen, since tillage promotes nitrification, which in turn causes a strong growth of wood.

12. *Excessive drought.*—Many attribute the shelling of grapes to the very dry weather. The grape season of 1894 was about ten days earlier than usual; Catawbas colored and ripened to perfection, and the quality of all varieties was exceptionally good. These undoubtedly are results of the drought, and why should not shelling be equally so since it has been so unusually severe? Several objections can be raised to this theory. If the shelling was due to the drought entirely, vineyards upon the same soils should have suffered with the same uniformity with which their grapes colored and ripened, or received their excellent flavor. Again, if drought is the only cause of shelling, vineyards growing upon moist soil should have been free from the trouble. One vineyard belonging to Mr. E. H. Fay, of Brocton, N. Y., was planted upon soil which remained moist throughout the summer; in fact, open ditches held running water during the worst of the dry weather. Nevertheless, this vineyard shelled, but not from want of water. It is situated upon the black rich land already mentioned and shelled probably for the same reason that others in similar situations did.

There seems to be, nevertheless, some connection between the prolonged dry weather and the shelling. It appears to me that this

* Messrs. Randall and Lewis, Ripley, N. Y.

connection can best be explained by the supposition that the dry condition of the soil prevented the plant food from going into solution, for unless it is in solution it cannot be taken up by the plant. This shortage of plant food, or defect of nourishment, would have a tendency to cause the plant to ripen its crop earlier than usual, which indeed did take place. But the grapes which fell to the ground were not fully ripened, nor were the majority of those which remained hanging upon these vines. The taste showed that there was something wrong in their development, that the sweetness and aroma proper to the variety were wanting. This was undoubtedly due to some defect in the nourishment of the berries, and this defect may have been and probably was intensified by the dry weather.

13. *Excess of moisture after drought.*—To what extent the rains which followed the drought influenced the shelling it is difficult to say. It is probable that the principal injury had already been done when these rains came, and the sudden supply of plant food may merely have hastened the last stages of the ripening of the berries and thus have caused them to fall a little sooner than they otherwise would have done. But to what extent this took place cannot be said.

14. *A weak root system.*—It is a generally conceded fact that young vineyards suffered more than old ones. Probably the severest cases could be found among vineyards which were bearing their second or third crop. Although many of the older vines suffered, the average loss from these was probably not so great as that from the younger plants. Since the younger plants were not so well established, they would not have the same opportunities of obtaining food as the older ones. The area covered by the roots would be smaller, they would not extend to an equal depth, nor would there be so many of them. This would result in an insufficient nourishment of the plant, a premature and probably an imperfect ripening of the fruit, and finally the falling of the berries. I think it very probable that in the case of the young vineyard belonging to Mr. E. H. Fay, already mentioned on page 428, that although the land was sufficiently rich in nitrogen it was lacking in some other equally important element; or, since the land itself is so very low and wet, it is very possible that it is not well adapted

to a healthy growth of the Concord grape. Either of these causes might tend to produce shelling.

That insufficient nourishment does cause grapes to shell is clearly shown in Figure 4. This Catawba cane was found in the vineyard of Messrs. King & Robinson near Trumansburg, N. Y. The first thing which attracted my attention was the light red color of the berries upon the central cluster. They were just



FIG. 4.—*Obstructed flow of sap the cause of shelling.*

turning, while the clusters on either side were colored a dark red. Upon closer examination the cause of the trouble became apparent. It will be seen in this illustration that the two outer clusters hang directly down from the underside of the cane. The stem of the central cluster, however, is attached on the upper side of the cane and the weight of the fruit has caused the stem to bend at a very acute angle, thus seriously interfering with the flow of sap.

Another interesting point was soon noticed. The lower berries

of the cluster separated in the same manner as that which takes place in the case of shelling; most of the berries parted regularly from the stem as if cut with a knife. The berries on the neighboring cluster parted in a different manner, for the connecting fibres remained attached to the peduncle, as shown in the figure. Here was positive proof that improper nourishment caused a marked weakening in the connection between berry and stem, and undoubtedly it was merely a matter of a short time before the berries would have shelled as completely as some others in the same vineyard were doing. With the others, however, it seemed to be a clear case of overbearing, which to the fruit is nothing more than a want of proper food.

15. *Want of barnyard manure.*—This cause for the trouble is here mentioned because Mr. H. B. Clothier, of Forestville, N. Y., assures me he has stopped the shelling by the use of barnyard manure which was taken from the stables of horses fed with grain. The use of stable manure, however, has not always been followed by such satisfactory results, and it may and sometimes does do injury by promoting an excessive growth of wood.

16. *Want of phosphoric acid.*—The lack of this substance in available form in the soil has been advanced as a possible cause of the grapes shelling. The use of phosphorus to the plant is very imperfectly understood. It is supposed to assist in the diffusion of soluble albuminoids, or those compounds which contain nitrogen. Nothing definite can be said of the relations existing between the shelling of grapes and the action of the phosphates.

17. *Want of potash.*—Probably more vineyardists agree upon attributing the shelling of grapes to a want of potash than they do upon any other cause advanced. There are several facts which favor the theory.

Potash is an essential element of plant food. Experiments carried on by Nobbe, Schroeder, and Erdmann* seem to prove conclusively that the office of potash in the plant economy is to assist in the formation of starch. Plants of Japanese buckwheat were grown in a solution free from all traces of potash. After a few

* Versuchs-Stationen, xiii. 1870, p. 357; cited by Goodale, Physiological Botany, p. 252.

weeks all growth had stopped. Examination of the plant failed to show any starch except traces in the green portion. When potash salts were added the plants began to grow again and starch was formed.

The development of sugar in fruits is dependent upon the presence of starch, for in the plant this substance is changed into the sugars, which sweeten the fruits. Some experiments have been made which have particular bearing upon this point. Dr. Stone, of the Massachusetts Agricultural College* makes the following statements: "A wild specimen of *Vitis Labrusca* (our common wild grape) was torn apart at its root; one half was left in its natural condition, the other transplanted to cultivated ground and treated with nitrate of potash and bone superphosphate. At the end of three years fruit from the cultivated vine contained twelve per cent. more potash and twenty per cent. more sugar than that from the wild one." Dr. Stone declared also that "potash fertilizers have decidedly improved the desirable qualities of our fruits. Wherever the percentage of this element has been raised the change is accompanied by an increase of sugar and decrease of acid." Other examples might be given, but these will answer for the present purpose.

All grape growers are agreed that the flavor of shelled grapes is none of the best; in fact such grapes are very insipid. Although this does not necessarily prove a lack of potash, the probabilities are that such is the case. All other causes which might produce such a result have been almost entirely excluded, so that we are apparently forced to accept this as the true cause of the difficulty. By a lack of potash is not meant necessarily that the soil is deficient in this element, but rather that it is not found in a form which makes it available as plant food.

The reasons for this want of potash are not very difficult to find. The lands upon which the majority of the Chautauqua vineyards are now growing had been used for many years for the production of grain and hay. Almost no fertilizers had been returned to the soil and the natural consequences followed. The supply of available plant food in the soil has become more or less exhausted.

*Amer. Gard. vi. 210 (1885), cited by Bailey, *Agricultural Science*, vi. No. II. 1892, p. 500.

In favorable seasons this may not be very apparent, but in seasons such as the past one, when the soil becomes dry and the quantity of available food in consequence more restricted, the effects of former croppings become visible upon lands which were not exceptionally rich in the first place. In the vineyard of Mr. S. Codington, of Fredonia, N. Y., this view of the case was very strongly emphasized. The vineyard is in the form of a square, and I was told that there was a strip stretching diagonally across the field from corner to corner, in which the vines shelled badly. Upon closer examination the line of shelling seemed to extend squarely across the vineyard in such a manner that about one-half shelled very badly, the other half but little. The portion which shelled the most was formerly used as a meadow and had been so used for fully twenty years. The other part had been set in the place of an old orchard which had been used as a cow pasture for more than twenty-five years. The line separating the orchard from the meadow could be traced plainly in the vineyard by the degree of shelling. There can be no doubt that much of the shelling is due to impoverished land.

It is not common to find a vineyard which was set upon old pasture or upon new land, that shells to any considerable extent ; most of these vines hold their fruit well and the contrary is the exception rather than the rule.

Fortunately we have proof that in some cases, at least, potash has stopped the shelling. But two examples can be here mentioned, but they are convincing.

Geo. W. Marsh, of Portland, N. Y., had been troubled with the shelling of his grapes for some years, on a rather low portion of his vineyard. Potash in the form of kainit was applied in the spring of 1894, at the rate of one pound per plant. This application seemed to be heavy enough, for the leaves did not show the "blight" during the following summer and the grapes did not shell in the fall. M. L. Taylor applied one ton of Canada hardwood ashes upon his vineyard ; it adjoins that of Mr. Marsh and is upon the same kind of land, but the applications were of practically no value. If the analyses of Canada hardwood ashes were always uniform, or if they invariably showed an abundant supply of potash, this result could hardly be explained. But in view of the success

which has followed the use of potash salts, I am inclined to believe that the ashes were not up to standard quality.

The second case is that of Mr. F. W. Howard, of Fredonia, N. Y. The experiment which was tried by Mr. Howard is one worthy of being followed by every grape grower in the Chautauqua district. He divided his Concord vineyard, which is practically level and is upon a soil very uniform in character, into several plots and applied fertilizers at the rate of two hundred pounds per acre, as follows :

16 rows, applied a mixture of equal parts muriate of potash and bone.

6 rows, muriate of potash.

6 rows, bone.

6 rows, tankage.

64 rows, equal parts tankage, bone, and potash.

7 rows, potash and bone.

4 rows, nothing.

These applications were made in the spring of 1894, upon land that had shelled in previous years. The results were so plainly marked that there was no room left for doubt as to the requirement of the land in this vineyard. The first plot of sixteen rows shelled, but not seriously. The next six rows, to which the muriate of potash had been applied, scarcely lost a berry, nor were leaves "blighted" to any greater extent than might be expected so late in the season. In passing to the next plot, the one to which the bone was applied, it was unnecessary to ask where the dividing line between the two plots was situated. The difference could be seen to the row. Where the bone had been applied, the berries shelled to such an extent that the ground was fairly blue in some places. It seemed as if fully one-third of the crop had fallen. The remainder of the plots showed improvements directly in proportion to the amount of potash used, the other materials applied being apparently without effect. The land upon which this vineyard stands was formerly used for farming purposes and was cropped continuously for fifty years or more with scarcely any fertilizers having been applied. The wonder is not that grapes shell, but that they do not all loosen their hold upon life and return to the soil from which they sprang.

GROUP IV.

Conditions of the atmosphere.

18. *Excessive heat.* If a very high temperature were the sole cause of grapes shelling, one should expect to find the shelling equally severe in vineyards having a similar exposure; and those vineyards in which the greatest heat occurred should show the worst shelling. But this is not the case. Some vineyards, and one belonging to Mr. E. H. Fay, of Brocton in particular, are so surrounded by trees that the south wind is the only one which can enter the vineyard freely. Mr. Fay told me that the heat in this vineyard was so intense that it is impossible for the men to work in it, and they are consequently given work elsewhere during the hottest days. The land has a southern exposure, it is protected on the north, west and partially on the east by trees, and it thus forms a pocket in which the heat accumulates sometimes to an intense degree. Yet this vineyard did not shell during the past season, with the exception of a small strip along the lower edge in which the soil was heavier and more moist.

19. *A south wind;*

20. *A west wind.*—These two causes have been advanced as being possibly responsible for the shelling. It has also been said that a north wind stops the trouble. At first thought it would seem that there can be no connection between shelling and the direction from which the wind blows. But, nevertheless, it is not impossible that such a relation may exist. A wind from the south or from the west is generally warm, and this warmth favors active growth and the development of the fruit. This activity of the plant may well be carried on at the expense of the fruit, especially if the supply of nourishment be limited. A north wind, being cool, would of course have an opposite effect, and check the plant's development.

Remedies.—After the above detailed discussion of the possible causes of the shelling of grapes it would appear that the one cause which appears to lie at the bottom of the trouble is *defective nourishment*. All influences which aggravate this condition may be held as being indirectly connected with the trouble, and they may even be the exciting cause of it. The drought, for instance, may

have had such an action on the supply of plant food that it prevented the plant from getting it, while if the season had been more favorable the vine might have pulled through and the owner would have been none the wiser.

The first step to take in order to remedy the shelling is unquestionably to study the needs of the soil in which the vineyard is growing. Mr. Howard is fully satisfied as to the needs of his vineyard, and it is very possible that his vineyard has suffered from shelling for the last time. I should hesitate to say that it is from a lack of potash that all the Chautauqua vineyards have shelled, yet it is probable that in a very large majority of cases this is the cause of the trouble.

Cultivation seems to have aggravated the trouble in soils which were not well supplied with all plant foods. It appeared to favor a growth which the plant was unable to ripen properly except at the expense of the fruit, for potash is as necessary to ripen wood properly as it is to add flavor to the berries. The much discussed subject of the amount of cultivation proper to a vineyard is here touched upon but cannot be discussed. The same rule will probably not apply to all vineyards; yet all cultivation which produces an excessive growth of wood and foliage should be avoided.

The weakening of vines by allowing them to overbear is another factor which seems to be responsible for some of the trouble. The young vines are the ones generally most seriously affected, probably because the roots do not penetrate into so much soil nor into such deep soil that a large food supply can be furnished the growing parts of the vines even under favorable circumstances. When young vines are allowed to bear heavy crops the food supply of those vines should be very carefully considered.

The powdery mildew was quite severe in many of the vineyards during the past season and a part of the shelling was without doubt caused by it. This mildew is one of the easiest to keep in check when it appears early in the season, but later attacks are more difficult to control as then there is danger of staining the fruit if late treatments are made. On page 441 will be found more definite directions regarding the treatment of this fungus.

Opinions of growers.—Having considered the possible and prob-

able causes of the shelling of grapes in a general way, it will be interesting to note how far actual cases will bear out the conclusions which have been reached. A circular asking for information was published and submitted to the growers of Chautauqua county. The following cases are replies which have been received and also answers obtained in personal interviews. They are here stated in an abbreviated form but, on the whole, contain the most important portions of the answers. The most severe cases of shelling are placed at the end of the list.

Ralph Hall, Brocton. *Soil*, strong shale and loam; *Fertilizer*, applied four hundred pounds low grade potash to a vineyard that shelled in past years; *Shelling*, none in 1894.

Jonas Martin, Brocton. *Soil*, strong gravel loam; *Fertilizers*, experience has proved that shelling is not so serious when potash fertilizers are used.

G. H. Barber, Westfield. *Soil*, some gravel and some loam. This is inclined to be dry, and originally was strong land; *Fertilizers*, in the fall of 1892 applied two hundred pounds bone flour, and in the following spring two hundred pounds muriate of potash. Also some barnyard manure. The vineyards cover twelve acres. *Shelling*, none except from two rows situated fifteen feet from a row of apple trees, these being about six inches in diameter. *Probable cause*, the roots of the apple trees robbing the grapes of nourishment.

S. Dean & Bros., Brocton. *Soil*, generally a rather heavy gravel loam, formerly used for farming purposes; *Fertilizers*, have been using stable manure and potash fertilizers during the past ten years. Make applications of about three tons of good ashes per acre. Ten years ago one piece shelled badly; nearly a wheelbarrow load of manure was put about each of several vines and the next year these did not shell, while those around them did. *Shelling*, at present practically none.

Geo. W. Marsh, Portland. *Soil*, heavy gravel loam, inclined to be wet in a low place; *Fertilizers*, used kainit, one pound per plant; *Shelling*, practically stopped where it was formerly serious and no blight on the leaves.

E. Buckner, Brockton. *Soil*, mostly gravel loam; *Fertilizers*, not manured lately, but formerly well fertilized with stable manure. Hay and grain were raised on the land for about twenty years previous to setting the vineyard. *Shelling*, very little on the gravel, more on low, heavier land.

A. W. Lewis, Brocton. *Soil*, high gravel; *Fertilizers*, none for many years. The vineyard weedy and apparently somewhat neglected. The land was formerly used for growing hay and grain, the vineyard now being from twenty to twenty-five years old. *Shelling*, none.

L. Roesch, Fredonia. *Soil*, dry gravelly loam, naturally poor; *Fertilizers*, two tons Canada wood ashes per acre, also some stable manure; *Shelling*, none.

Henry Case, Brocton. *Soil*, gravel loam; *Fertilizers*, applied two tons of Canada ashes in spring of 1894 upon seven acres; *Shelling*, one part of the vineyard is eight years old and this shells; the other part is thirty years old, but does not shell.

Hermion L. Kent & Co., Westfield. *Soil*, mostly dry clay, originally poor; *Fertilizers*, yearly application of stable manure; *Shelling*, none. Insects the probable cause of shelling, and not lack of vitality in the vines. Some of the very richest and best land has shelled grapes.

A. H. Harris, Westfield. *Soil*, rich, dry gravel; *Fertilizers*, one pound sylvinite to the vine; *Shelling*, none where potash was used, some where it was not used.

A. N. Taylor, Westfield. *Soil*, a dry gravel, naturally rich; *Fertilizers*, potash at the rate of four hundred pounds per acre; *Shelling*, less than one per cent.

Professor W. A. Holcomb, Ripley. *Fertilizers*, applied one ton of sulphate of potash on ten acres in 1893, and this year a light dressing of wood ashes; *Shelling*, none.

O. J. Tefft, Ripley. *Soil*, gravel with low places; *Fertilizers*, used one quart of good maple ashes per vine; *Shelling*, most of the vines shell, particularly in the low muck ground.

G. Schoenfeld, Westfield. Formerly had charge of a vineyard. *Soil*, gravelly loam; *Fertilizers*, one, to one and one-half pounds of muriate of potash applied in the spring to the vines which shelled the fall before, stopped the trouble.

E. W. Skinner, Portland. *Soil*, gravelly loam; *Fertilizers*, applied half a pound of German potash salts to plants when they were set several years ago. About the same amount used again in 1893. *Shelling*, nearly twenty per cent.

J. A. H. Skinner, Brocton. *Soil*, 1, a heavy sandy loam, rather low, and formerly used for pasture; 2, a gravel loam, high ground, formerly used as a garden; 3, a lighter soil used for raising grain; 4, shale loam, upon which stood an orchard; *Fertilizer*, none; *Shelling*, piece 1, none; 2, about 5 per cent.; 3, from 15 per cent. to 25 per cent.; 4, none along the borders of the vineyard, from 1 per cent. to 10 per cent. in the interior.

Chas. Payne, Brocton; *Fertilizers*, much stable manure used continually; *Shelling*, the vineyard was set three years ago. This year it set heavily and shelled severely.

A. Kelly, Brockton. *Soil*; varies, sand, loam, clay; *Fertilizers*, applied two hundred pounds raw bone meal per acre where the plants were set six years ago. Since then four hundred pounds of potash have been applied twice. *Shelling*, about 5 per cent., there being apparently no difference in severity on the different soils.

George S. Kent, Westfield. *Soil*, a loam inclined to be heavy and poor; *Fertilizers*, mostly horse manure for several years. Last year used on a part sulphate of potash costing \$50 per ton, and some years before ashes to a considerable extent. *Shelling*, none except on three or four Concord vine

growing in an alluvial deposit of several inches of dark soil. It is the richest part of the vineyard and I never added manure thinking it needed none.

E. H. Pay & Son, Portland. *Soil*, side hill of loam and coarse gravel inclined to be dry. It is rather shallow and poor and was used not less than fifteen years as a cattle and horse pasture; *Fertilizers*, none. *Shelling*, only occasionally a bunch.

T. J. Walker, Ripley. *Soil*, both gravel and clay soils, well drained and fairly rich; *Fertilizers*, applied potash in 1893 at the rate of one pound to the vine, and also stable manure. *Shelling*, about 1 per cent.

A. W. Rumsey, Westfield. *Soil*, rolling, the hollows being of soil worked down into them, and all quite well drained; *Fertilizers*, a very little stable manure. *Shelling*, about 1 per cent., occurring mostly in the lower parts of the vineyard. *Probable cause*, a superabundance of foliage absorbing all the moisture during drought at the expense of the fruit.

Fraser & Co., Westfield. *Soil*, gravelly loam and sandy loam. Was cropped in parts for many years with grain and hay; *Fertilizers*, wood ashes and bone in some sections, muriate of potash and mixed fertilizers in others, and occasionally a little compost of stable manure. *Shelling*, lost by shelling probably 2 per cent. to 3 per cent.

A. B. Hawkins, Ripley. *Soil*, dry gravelly loam, naturally rich; grain and grass grown for many years; *Fertilizers*, animal manures. *Shelling* from 2 per cent. to 5 per cent., but where the manure was applied the grapes did not shell.

Jno. W. Spencer, Westfield. *Soil*, shaley clay with bed rock within thirty inches of the surface; *Fertilizers*, two years before being on the vine applied a shovel of stable manure to each plant each season. First crop nothing; second crop, four hundred pounds muriate of potash and four hundred pounds bone on one and three-fourths acres; third crop (1894) one hundred pounds unleached hardwood ashes on the same land. *Shelling*; shelling goes by plants, some plants 50 per cent., average 5 per cent. on piece of one and three-fourths acres. [While in conversation with Mr. Spencer he said that the worst shelling was in those portions of the vineyard in which the underlying rock came nearest the surface. E. G. L.] *Probable cause*; fungous disease on part or whole of them; plants not having proper formula of food are most susceptible to disease.

Chas. E. Brown, Ripley. *Soil*, rich black loam, rather wet; *Fertilizers*, heavy dressings of barnyard manure. *Shelling*, 5 per cent. *Probable cause*; might be mildew, is usually worst where vines have the most foliage.

B. M. Taylor, Portland. *Soil*, mostly rich, dry gravel with occasional hard loam in low places; *Fertilizer*, one portion barnyard manure, another salt and ashes. *Shelling*, none. *Probable cause*, drought and want of fertilizer. One of the worst vineyards I had last year received a good dose of salt and ashes and this year it has the best fruit of any and does not shell.

R. G. Wright, Westfield. *Soil*, rich black loam, clay subsoil. *Fertilizers*, not any until last spring when I applied potash at the rate of five hundred

pounds per acre upon one-half, and fourteen two-horse loads of rich horse manure upon the other half. *Shelling*, none, except six rows which I did not fertilize. These shelled badly.

M. L. Taylor, Portland. *Soil* similar to that of Mr. Geo. W. Marsh and adjoining it. *Fertilizers*, applied one ton Canada ashes in 1893 and in 1894 repeated the application. *Shelling*, apparently not benefited by the ashes and about 40 per cent. of the grapes dropping in the worst portions.

S. S. Grandin, Westfield. *Soil*, a dry shale, originally not very good; used about 10 years in raising grain. *Fertilizers*, on the shale none. *Shelling*, 30 per cent. to 40 per cent. On other land that was manured the shelling was from 13 per cent. to 20 per cent.

E. H. Fay & Son, Portland. *Soil*, low, flat land consisting of rich, black muck. It was used for growing hay for twenty-five years before the vineyard was set. *Fertilizers*, none. *Shelling*, about 20 per cent. *Probable cause*, extremes of wet and dry weather.

E. D. Warner, Forestville. *Soil*, part gravel and part muck mixed with loam, this last being inclined to be wet. *Fertilizers*, the land has had barnyard manure more or less for twenty-five years, during which time it was used for meadow. Last fall, and the fall before, applied one shovel barnyard manure about each plant. *Shelling*, from 12 per cent. to 25 per cent. of the crop. *Probable cause*; about here the vines do not shell so much on clay land as upon other soils; they seem to be worse also upon richer lands. There is a meadow on the west side of my vineyard and the two rows next the meadow do not shell; the third row but little, and the trouble increases towards the center of the vineyard. Nor is there any shelling at the ends of the rows.

Franklin Peck, Westfield. *Soil*, not very good and naturally rather poor. *Fertilizers*, none worth mentioning. *Shelling*, 20 per cent.

Frank Maginnis, Portland. *Soil*, clay loam, poor, thin, and dry. During four years previous to setting the vineyard the land was sown to oats, two hundred and fifty pounds of phosphates being used to the acre. The average yield of oats was thirty bushels per acre. *Fertilizers*, in setting vines used high grade phosphates; in 1893 used twenty-five hundred pounds of high grade potash on ten acres. That is the part that has shelled the worst. Have used no other fertilizers in six years. *Shelling*, nearly 25 per cent.

R. A. Hall, Brocton. *Soil*, black rich loam, rather wet. *Fertilizers*, none. *Shelling*, 50 per cent.

C. M. Whitmier, Brocton. *Soil*, gravelly loam, well drained. *Fertilizers*, applied liberal quantities of a mixture of tankage, bone meal, dried blood, and sheep manure to the first row or each side of a road passing through the vineyard. *Shelling*, very little on the treated rows, 20 per cent. to 30 per cent. on the rows back of the first ones.

B. POWDERY MILDEW.

(Uncinula spiralis.)

The appearance of this mildew has been described on page 423. The fungus begins to attack the grape early in June and then continues to spread with greater or less severity throughout the growing season. Dry weather seems to assist in holding it in check, and warm rains are sometimes followed by very severe attacks.

The early applications which were formerly recommended in the treatment of most of the diseases of the grape are not now so strongly insisted upon. For the treatment of the powdery mildew, the following applications should be sufficient. The Bordeaux mixture or the ammoniacal carbonate of copper may be used (see page 450, 451). It is perhaps better to use the Bordeaux early in the season, and later the ammoniacal solution.

First application, about a week before the blossoms open.

Second application, about a week after the blossoms fall.

Third application, about two weeks after the second treatment.

Fourth application ; in many cases this can be omitted entirely. The time for making it cannot be definitely stated, but it may be required some time within two to four weeks after the third.

Mr. J. A. H. Skinner, of Brocton, has been very successful in controlling this mildew by the use of the ammoniacal solution alone. As this is much more easily applied, it may be safe to use it exclusively. In making the applications care should be taken to *strike the clusters* as well as the foliage, for where there is none of the fungicide there the mildew has a chance. Later in the season the application should be directed more to the foliage, for fear of staining the fruit.

As yet, the Chautauqua vineyards have been apparently almost free from other fungous diseases and the advisability of spraying is an open question. During the past season the powdery mildew does not seem to have been sufficiently severe to warrant spraying beyond exceptional cases. What the conditions will be next year it is impossible to say.

C. ANTHRACNOSE.

(Sphaceloma ampelinum.)

Upon certain varieties, as Moore's Diamond, Brighton and others, anthracnose is sometimes very severe. It attacks the green stems, leaves and fruit, and sometimes causes a total loss of the crop.

The first indication of the disease upon the stems is the appearance of small dark brown or black spots, sunken in the central portions. These spots enlarge, generally extending up and down the stem, thus forming oval-shaped areas. Sometimes, however, the disease encircles the stem in such a manner as to girdle it and the result is similar to that which would occur if the girdling had been due to some other cause. This form of the disease is particularly prevalent upon the stem of the grape cluster. Here it is sometimes called "ring-around." As the disease progresses, the central portion of affected areas becomes more sunken and finally assumes an ashen color, only the edges of the affected part retaining the dark color.

On the fruit, the first stages are similar to those in the stem. The affected part is, however, often surrounded by a band having a reddish tinge and the center does not always assume the same ashen color, but it remains rather a dark brown. The diseased surface is quite smooth, and sometimes measures a quarter of an inch in diameter. If the berry is attacked while young, or if attacked in several places when grown, it is of no commercial value.

Anthrachnose of the grape is the most obstinate disease which the New York vineyardists have to combat. No authenticated cases are on record showing that the disease has been successfully treated by the use of the Bordeaux mixture or of any other fungicide after the foliage has expanded. In fact, I do not know of a single case in which the disease has been kept under control in this state, whatever the method followed.

The anthracnose of the grape is probably of European origin. It was introduced into this country fifteen years ago or more, and has since spread into most sections in which grapes are grown. In Europe it has long been successfully treated, but whether the same remedies will answer equally well in this country still

remains to be seen. The following is the method commonly employed by the foreign vineyardists :

Early in spring, just before the buds begin to swell, the arms and canes, including the buds, are treated with a solution made of sulphate of iron (copperas), sulphuric acid, and water in the following proportions :

Sulphate of iron,	110 pounds.
Sulphuric acid (commercial),	1 quart.
Water (hot),	26 gallons.

Care must be taken first to pour the acid upon the sulphate of iron crystals, and only then the water may be added. Otherwise there is danger of the water and acid being spattered when the two come in contact. This solution should be used the day it is made, for the iron sulphate will re-crystallize upon cooling if the liquid is allowed to stand any length of time.

Owing to the caustic properties of this solution it cannot be applied with our common spray pumps. The method followed in France is to tie a bundle of rags at one end of a stick and with this swab the vines are carefully treated. All portions of the vine that are covered turn black and in case the work has not been well done another application is made, but only the light-colored portions then receive attention.

The principal objection to this remedy is its expense and this will prove a serious drawback to the adoption of the method in this country. The vines can scarcely be injured by the application for I have used a similar solution which contained ten per cent. of sulphuric acid upon swelling buds, to the injury of about one-half of them. This remedy will be given a further trial and reported upon.

PART II—IN CENTRAL NEW YORK.

ANTHRACNOSE.

POWDERY MILDEW.

SHELLING.

These troubles are found to a limited extent in central New York, but the conditions are so similar to those in Chautauqua county that what applies to one region will apply to the other also. But other diseases have also been present this year and they will be briefly discussed.

D. BLACK ROT.

(*Laetitia Bidwelli*.)

Black rot was very prevalent in the vineyards situated on the banks of most of the lakes of central New York. Some untreated vineyards lost from fifty to seventy-five per cent. of the crop from this disease, and even some treated vineyards showed a large amount of worthless fruit. Some vineyardists have said that the more the vines were sprayed the worse the rot became and many feel discouraged over the results of the season's work.

The black rot fungus attacks the berries most severely. Upon them it first manifests itself, generally when the berry is about full grown, by producing a brown or purplish spot upon one side. This color gradually extends over the entire berry and in the course of a few days the surface assumes a uniform dark brown appearance, which is deeper, however, in the portion first affected. This part begins to turn darker and produces many small, black pimples, these being a very characteristic feature of this disease. The berry now begins to shrink and dry, but it remains hanging on the stem until late in the season, sometimes throughout the winter.

"In the leaf the fungus causes well defined reddish brown spots of varying size, usually rounded in outline, and dispersed on the parts between the principal nerves. These spots usually

appear some days or even a week or two before the berries are attacked. On the young shoots and leaf stalks it effects characteristic changes in the form of elongated, very dark brown or black spots, which are slightly depressed owing to the absorption of the juices from the cells composing the underlying tissues,



FIG. 5.—*Catawba clusters and black rot.*

Not sprayed.

Sprayed.

over the surface of which the characteristic pimples or pustules are more or less thickly scattered."*

The treatments for the black rot are very similar to those mentioned on page 441. One fact should, however, be kept constantly in mind: the black rot is a very energetic disease and a berry affected with it is ruined. The fungus does not appear until rather late in the season, generally not until the fruit is fully two-thirds grown. This makes later applications dangerous on account of the necessary staining of the fruit. It is therefore

*Scribner. *Fungous Diseases of the Grape and Other Plants*, p. 10.

essential for the satisfactory control of the black rot that the early application be made *as thoroughly as possible* and upon the same dates as given for the first treatments of the powdery mildew. If the rot is feared, the last applications should be made more frequently, and as long as there is no danger of a permanent staining of the fruit the clusters should be thoroughly treated. The ammoniacal carbonate of copper should be used after the middle of July, or the first of August at the latest. It is better to use the Bordeaux mixture early in the season. The total number of applications necessary to control the black rot varies from three to seven, depending upon the dampness and temperature of the summer months. In warm weather, when the air and soil are kept moist by frequent showers, the disease often spreads with extreme rapidity, and under such conditions the treatment must be repeated every seven to ten days. Among some Seneca lake vineyardists there has arisen the impression that the more they spray the worse the rot becomes. Such a state of affairs is of course impossible. The applications made were probably not followed by as good results as was expected but that must be the fault of the operator and not of the mixture. One cause of this trouble was quite evident. The vines were a mass of foliage, so that it seemed impossible to reach the individual clusters in spraying. The land was also very rich in nitrogen so that the conditions were favorable to fungous growths. The absolute necessity of thorough work cannot be too strongly emphasized. Figure 5 represents two clusters of Catawbas, the one on the left not treated, the one on the right treated according to the above directions. In this case absolute protection was afforded by the spray.

E. BROWN ROT, GRAY ROT.

(*Peronospora viticola*.)

This disease is also caused by a fungus which thrives upon all the green portions of the grape.

It may attack the berries any time during the growing season but is as a rule more serious early in the summer. Diseased berries stop growing and soon becomes covered with a mealy substance which gives them a gray appearance. This has caused the disease to be called a gray rot. When the berries are more

advanced at the time the fungus attacks them they turn brown, which has given rise to the name of brown rot, and the gray appearance is not always present. Figure 6 shows two clusters of Niagara grapes attacked early in the season.



FIG. 6.—Young *Niagara* clusters attacked by brown or gray rot.

The leaves and young shoots also suffer early in the year but the worst time for them appears to be during July. Still I have seen comparatively fresh growth of the fungus as late as October, so that there is danger from the disease so long as there are green portions upon the vine. The fruiting portion of this fungus appears upon the under side of the leaves in the form of gray, downy growths. Directly above these the upper side of the leaves show yellow discolorations which soon turn brown as the affected part of the leaf dies. These areas are quite sharply defined, and the entire leaf does not change color in consequence of such diseased portions.

The stems when mildewed show the same gray appearance on their surface as is seen on the under side of the leaves. In severe cases the fungus kills the stem outright beyond the diseased portion, and a general browning of these parts takes place.

The downy mildew is not so serious late in the season as is the black rot, and this necessitates particular care in making the early applications. The Bordeaux mixture and the ammoniacal carbonate of copper are the safest fungicides to use. The applications should be made as already recommended for the powdery mildew, but greater thoroughness must again be insisted upon, as the disease is more serious than the powdery mildew.

F. RIPE ROT.

(*Glaspodium fructigenum*.)

A disease which to all appearances was the ripe or bitter rot of grapes was seen in some vineyards about Keuka lake. This year the injury done was not serious, but it is evident that the disease exists in this region and it may cause severe losses if the proper conditions for its development are present.

Affected berries change color in the portion first attacked, and this discoloration gradually spreads over the entire berry changing it to a reddish brown. Here the berry remains and shrivels, often hanging to the stem until quite dry, or sometimes dropping to the ground as soon as the shrivelling begins. Pimples appear on the surface of the shrunken portions, but such berries can be distinguished from those attacked by the black rot by their not being of such a black color. They are generally a clear brown or deep purple.*

This disease appears to attack grapes later than does the black rot, which makes it rather difficult to control. But the applications designed for black rot, if thoroughly made, will also check the progress of this disease.

G. DROUGHT.

In several vineyards on the shores of Canandaigua lake were noticed vines which had lost most of the lower leaves from the

* Scribner; *Ibid.* pp. 38, 39.

canes, thus leaving the fruit entirely exposed to the direct rays of the sun. The trouble seems to have begun during the latter part of summer. The leaves turned yellow and then brown, this last color generally appearing in those parts of the leaf situated farthest from the main veins. One-half of the leaf was in some cases destroyed before the other part seemed to suffer. The majority of such cases seemed to occur in portions that were directly exposed to the full force of the sun's rays. Such leaves were more or less curled, or they were so placed that one part shaded another. As a rule, the shaded portion did not suffer much until the part that received the sunlight was very seriously affected. Then the whole leaf gradually yielded to the trouble. The final result was that all the more seriously affected leaves eventually dried and fell from the vines, giving the vineyard a thin and unhealthy appearance.

The cause of the trouble was probably the dry weather, for the thinner the soil and the more it dried out, the worse the trouble seemed to become. Some entire vineyards were injured, others suffered only in certain portions, and those which were upon moister ground did not suffer at all. As soon as the fall rains came, the falling of the leaves immediately stopped.

Any cause which will tend to retain moisture in the soil will lessen the severity of the trouble. The worst case seen was in a Delaware vineyard that had received apparently no cultivation. If a thin mulch of cultivated soil had lain upon the ground, the evaporation would not have been so great and the vines would not have suffered as they did. More expensive and effective remedies can hardly be recommended at present.

PART III—MACHINERY FOR SPRAYING—FORMULAS.

The machinery to use in spraying vineyards and other plantations should be as simple and effective as possible. Three general styles are now in use ; knapsack pumps, hand pumps, and power sprayers.

The knapsack pump is probably the most effective, for the spray is entirely under the control of the operator and the work can be done as thoroughly as desired. It is open to the objection of being hard to carry and to work, and it is also very slow.

The hand pump, when placed on the side of a barrel and mounted in a wagon, makes a very serviceable outfit on level ground. It allows the use of two nozzles, and possesses greater power than the knapsack. A good arrangement is to have one man drive and hold one nozzle while the other man pumps and holds the other nozzle.

Power sprayers are the easiest to use, for in them the horse does the pumping. My experience with these has been such that I am convinced that for all low growing plants they are the most satisfactory machines to use. They must be adapted to the work, and be properly built and handled to give the best results. If a good machine is used, the work will be done about as effectively as with a hand pump, and much more easily. Some New York vineyards have been kept practically free from fungous diseases by their use.

The best nozzles for such work are probably the Vermorel, the McGowen, or the Bordeaux. These can be graduated, are easily cleaned, and are durable.

FORMULAS.

Bordeaux Mixture.

Sulphate of copper, 6 pounds.

Quick lime, 4 pounds.

Water, 40 to 50 gallons.

Dissolve the sulphate by hanging it in a bag in the liquid at the top of a wooden or earthen vessel full of water. One gallon of water will dissolve from one to two pounds of the sulphate. The lime should be slaked in an equal volume of water and when the

two are ready they can be poured the one into the other and then thoroughly stirred.

Another way of making the Bordeaux mixture has recently come into use. The sulphate of copper is used at the same rate as above but it is dissolved so that every gallon of the solution shall contain one pound of the sulphate. Then for the above formula six gallons would be taken and to this milk of lime is added until the ferro-cyanide of potassium will not discolor the mixture when a drop or two are added to it. So long as there is not sufficient lime present the test will show a dark brown discoloration where the material falls. When enough lime has been added no change takes place. The test solution is made by dissolving about an ounce of the ferro-cyanide of potassium in a pint of water. Only a drop or two need be used at a time, when making the mixture. I should recommend adding more lime than the test shows to be necessary, for from the experience of the past season the Bordeaux mixture has in some cases done serious damage to fruit. This subject will be more fully discussed in a future bulletin.

Ammoniacal Carbonate of Copper.

Carbonate of copper, one ounce.

Ammonia, enough to dissolve the copper.

Water, nine gallons.

The copper carbonate should first be moistened with a little water and the ammonia then added. This stock solution should be kept tightly corked until used. It will keep indefinitely. When wanted, dilute to the required extent with water, and apply.

Iron Sulphate and Sulphuric Acid Solution.

(French, for Anthracnose).

Sulphate of iron, 110 pounds.

Sulphuric acid (commercial), 1 quart.

Water (hot), 26 gallons.

First pour the acid upon the iron crystals and then add the hot water. As soon as the crystals are dissolved the solution is ready for use and should be applied the same day if possible. Do not apply this by means of metal apparatus for the acid will corrode

and render it worthless. Apply with a cloth swab, and only to dormant plants.

SUMMARY.*

PART I.

1. The shelling of grapes occurred to a very serious extent in 1890 and 1894. Page 418.

2. This disease is probably not identical with *apoplexie* or with *rougeot*, two diseases occasionally present in French vineyards. Pages 420, 421.

3. Insects do not cause the disease. Page 423.

4. Fungi, especially the powdery mildew, may aggravate the condition to a limited extent, but they cannot be held as the prime cause of the trouble. Page 423.

5. The "blight" or unnatural dying of the foliage is not the cause of the malady, but is probably a manifestation of the action of the same causes which produce the shelling of the grapes. Page 424.

6. The stems shrivelling before the berries mature is another condition produced by the same cause. Page 425.

7. The premature ripening of the berries is due to the same causes as the blight of the leaves and the abnormal condition of the fruit stems. Page 425.

8. The premature ripening of the wood, while it may to a certain extent be the cause of the shelling, can scarcely be considered as the fundamental cause of all the trouble. Page 425.

9. Vines which are allowed to overbear are probably more liable to shell than are those not in the same condition. The weakening of a plant causes it to succumb more easily to unfavorable conditions. Page 425.

10. Too much wood may increase the extent of the trouble, for when the wood ripens it apparently takes its required nourishment at the expense of the fruit. Page 426.

11. Too rich land will scarcely cause shelling provided the

* NOTE.—The conclusions regarding the shelling of grapes have been drawn almost entirely from one season's observations, and the subject should receive further attention in the future.

available food supply is present in proper proportions for the use of the plant. Page 426.

12. Nitrogen apparently increases the amount of shelling. Lands which are rich in this element of plant food seem to suffer more than those growing in land that makes a smaller growth of wood. Page 427.

13. The shelling of grapes upon soils rich in nitrogen is probably not due to an inherent tendency of the nitrogenous food to produce shelling, but rather to a faulty ratio between the amounts of available plant food. Page 427.

14. The kind of soil, not considering the food supply contained in it, does not appear to exercise any marked influence upon the degree of shelling. Page 427.

15. Too much cultivation seems to aggravate the trouble, probably on account of the larger amount of nitrogenous food liberated by the operation. Page 427.

16. Excessive drought alone cannot be held as the sole cause of the trouble, although it is probable that the dry weather caused the loss to be greater than it would otherwise have been. Page 428.

17. Excessive rains after a prolonged drought may have influenced the severity of the shelling but to what extent is not known. Page 429.

18. A weak root system would have an effect upon a plant similar to that exercised by allowing it to overbear, and a like tendency towards shelling would exist. It seems probable from the fact that young vines, as a rule, shell the most, that the limited root system may be in part responsible for the trouble. Page 429.

19. A want of barnyard manure has been ascribed as a cause, and the trouble, in one case, has been stopped by its use. Page 431.

20. No evidence at hand goes to show that shelling is due to a want of phosphoric acid. Page 431.

21. Many vineyardists have apparently stopped the shelling by applications of potash. Page 431.

22. Potash seems to be the food required by the plant in the majority of the cases in which the vines shell and it may be wanted in all cases. Page 432.

23. The principal reason for this lack of potash is undoubt-

edly the continuous cropping to which most of the shelling land was submitted before the vineyards were set. Page 432.

24. Excessive heat of itself did not cause the shelling. Page 435.

25. A warm wind, one which would have a tendency to excite active growth, might have a tendency to increase the shelling. Page 435.

26. A cool wind or cool weather, on the contrary, may stop the trouble to a considerable extent. Page 435.

27. Powdery mildew was quite prevalent in Chautauqua county in 1894, but it is certain that the usual remedies will check the disease. Pages 436, 441.

28. Anthracnose is serious in some localities and it is recommended that growers make a trial of the acid sulphate of iron solution, as described on page 443.

PART II.

29. Shelling, anthracnose, and powdery mildew exist also in the lake region of central New York. The remedies already mentioned are recommended.

30. Black rot, brown rot, and ripe rot appear to have done some injury in this region during the past season, and the usual remedies are recommended. Pages 444, 446, 448.

31. The failure of some vineyardists to prevent these diseases was probably owing to a too heavy growth of foliage, and to improper methods of making the applications.

32. Drought caused some vineyards to suffer severely. Shallow and frequent cultivation is probably the most practical method of counteracting this influence. Page 448.

PART III.

33. A knapsack sprayer is the most effective machine, but it is the hardest to work and the slowest in covering the plants. Page 450.

34. Hand pumps allow of much more rapid work, but the work is not always so effective. Page 450.

35. Power sprayers, under favorable circumstances, are the most desirable machines for spraying vineyards. Page 450.

E. G. LODEMAN.

30.679
✓
C 826

UNIV. OF MICH.

JAN 18 1909

Bulletin 77.

November, 1894.

Cornell University Agricultural Experiment Station.
HORTICULTURAL DIVISION.

THE Grafting of Grapes.



By E. G. LODGMAN.

PUBLISHED BY THE UNIVERSITY,
ITHACA, N. Y.
1894.

ORGANIZATION.

BOARD OF CONTROL: THE TRUSTEES OF THE UNIVERSITY.

STATION COUNCIL.

President, JACOB GOULD SCHURMAN.				
Hon. A. D. WHITE,	-	-	-	Trustee of the University.
Hon. JOHN B. DUTCHER,	-	-	-	President State Agricultural Society.
Professor I. P. ROBERTS,	-	-	-	Agriculture.
Professor G. C. CALDWELL,	-	-	-	Chemistry.
Professor JAMES LAW,	-	-	-	Veterinary Science.
Professor A. N. PRENTISS,	-	-	-	Botany.
Professor J. H. COMSTOCK,	-	-	-	Entomology.
Professor L. H. BAILEY,	-	-	-	Horticulture.
Professor H. H. WING,	-	-	-	Dairy Husbandry.
Professor G. F. ATKINSON,	-	-	-	Cryptogamic Botany.

OFFICERS OF THE STATION.

I. P. ROBERTS,	-	-	-	-	-	Director.
E. L. WILLIAMS,	-	-	-	-	-	Treasurer.
H. W. SMITH,	-	-	-	-	-	Clerk.

ASSISTANTS.

M. V. SLINGERLAND,	-	-	-	-	-	Entomology.
GEO. C. WATSON,	-	-	-	-	-	Agriculture.
G. W. CAVANAUGH,	-	-	-	-	-	Chemistry.
E. G. LODEMAN,	-	-	-	-	-	Horticulture.
MICHAEL BARKER,	-	-	-	-	-	Horticulture.

Office of the Director, 20 Morrill Hall.

Those desiring this Bulletin sent to friends will please send us the names of the parties.

BULLETINS OF 1894.

62. The Japanese Plums in North America.
63. Co-operative Test of Sugar Beets.
64. On Certain Grass-Eating Insects.
65. Tuberculosis in Relation to Animal Industry and Public Health.
66. Test of Cream Separators.
67. Some Recent Chinese Vegetables.
68. The Cultivated Poplars.
69. Hints on the Planting of Orchards.
70. The Native Dwarf Cherries.
71. Apricot Growing in Western New York.
72. The Cultivation of Orchards.
73. Leaf Curl and Plum Pockets.
74. Impressions of the Peach Industry in Western New York.
75. Peach Yellows.
76. Some Grape Troubles of Western New York.
77. The Grafting of Grapes.

CORNELL UNIVERSITY, ITHACA, N. Y., Nov. 6, 1894.

THE HONORABLE COMMISSIONER OF AGRICULTURE, ALBANY.

Sir.—The average yield of grapes in western New York in good years is one and three-fourth tons to the acre. This is half or less the yield of the best vineyards. This low average is due to many causes, but one of the chief is the persistent growing of unproductive varieties. The most ready means of correcting this fault is to graft the unprofitable varieties, but growers are, in general, ignorant of the process. The following account, therefore, drawn from our own experiments, and from the experience of vineyardists in western New York, is prepared for the purpose of supplying this information ; and it is submitted for publication and distribution under section 87, chapter 675, of the laws of 1894.

L. H. BAILEY.

THE EXPERIMENT STATION EXTENSION, OR NIXON, BILL.

A law was made last winter appropriating \$8,000 to be expended by Cornell University for the benefit of horticulture in the Fifth Judicial Department of the State—an area comprising the counties of Cayuga, Seneca, Yates, Steuben, and all counties to the westward. This fund is to be expended “in conducting investigations and experiments in horticulture; in discovering and remedying the diseases of plants, vines and fruit trees; in ascertaining the best means of fertilizing vineyard, fruit and garden plantations, and of making orchards, vineyards and gardens prolific; in disseminating horticultural knowledge by means of lectures or otherwise; and in preparing and printing, for free distribution, the results of such investigations and experiments, and such other information as may be deemed desirable and profitable in promoting the horticultural interests of the State.” All this work is to be prosecuted by Cornell University “under the general supervision and direction of the Commissioner of Agriculture.”

This bill became a law so late in the season, that few particular lines of experimentation could be attempted which should give results the present year. But an effort has been made to complete a somewhat thorough survey of the horticultural industries of the Fifth Judicial Department, and the results of this undertaking are now appearing in bulletin form. Bulletins 69, 70, 71, 72, 74, 75, 76 and 77 belong to this series, and others, so far as the fund will allow, are forthcoming. It is hoped that these reports, by discovering and recording the present state of the interests of which they treat, may form the basis for exact experimentation, if such is desired in the future. Every good farm is, in an important sense, an experiment station, but its teachings, in order to be valuable and of use to the commonwealth, must be studied by a trained and disinterested observer. Such results, when published, are of inestimable value, because they arise from normal and practical conditions; and they inspire a confidence and sympathy which investigations conducted at a central experiment station can scarcely hope to awaken.

Yet, certain experiments are already well under way. Somewhat extensive investigations of the actual fertilizing of orchard lands are progressing in various parts of western New York; and about 500 acres of fruit plantations have been sprayed directly or indirectly through our efforts, and the results have been subjects of careful study. Aside from these, many special experiments are in progress in the interest of the law, the precise nature of which will appear as the investigations mature. It should also be said, that an important feature of the operation of the Nixon law, is the opportunity which it extends to every horticulturist in the Fifth Judicial Department to have his particular difficulties investigated, and to receive direct advice from persons who are expert in particular directions.

In order to fully secure the benefits of the law, it is necessary that horticulturists freely coöperate with us in the way of furnishing information, in allowing us the use of plantations for study and experiment, and in laying before us the difficulties under which they labor.

L. H. BAILEY, *Officer in Charge*,
ITHACA, N. Y.

GRAPE GRAFTING.

INTRODUCTORY.

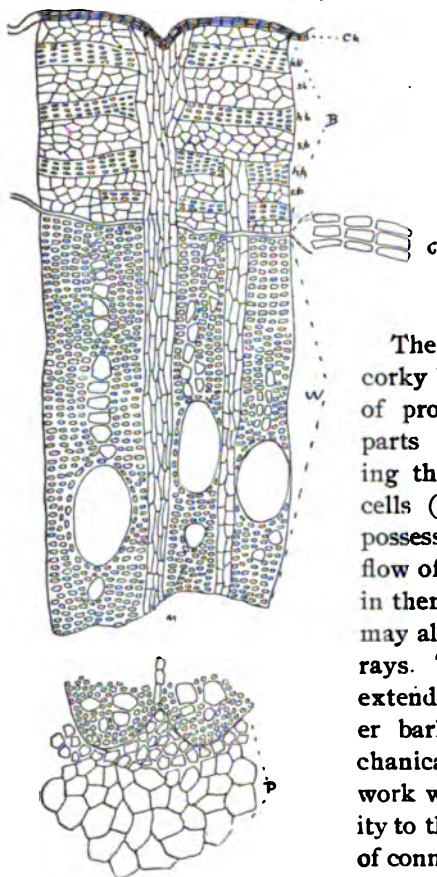
The grafting of grapes is a subject which is increasing in importance as grape growers become more familiar with the varieties which are now growing in their vineyards. Many bearing vineyards are not giving such satisfactory returns as were expected and in many cases it is often largely owing to the fact that the proper varieties have not been selected. Or a certain district may be especially adapted to the growing of particular varieties, and it seems to be desirable to alter vineyards now in bearing so that they will produce the desired fruit without the loss of time which would result from tearing up the old plants and setting new ones. These and similar causes have forced vineyardists to turn their attention to the grafting of their vines, and several have already done considerable work of this character. In this article herbaceous, or soft wood grafting, will not be considered, as it is rarely used upon the grape. Various experiments upon a practical basis have been made during the past two or three years by the writer and his former associate, L. C. Corbett, now professor of horticulture and forestry in the Agricultural College of South Dakota.

Structure of the stem.—Hard wood grafting is not a difficult operation when a few essential points are observed. From ninety-five to one hundred per cent. of the grafts should grow when the work is carefully done, and skill in performing the operations is soon acquired....

Figure 1. represents a cross-section of the stem of a grape, and an understanding of the general character of the different parts will assist in explaining the reason of the successes as well as of the failures which will occur with all operators.

The corky external layer (c k) as well as the bark (B) immediately underneath it are composed of cells which have ceased

to grow. The same may also be said of the cells of the wood (W), of the medullary rays (M), and of the pith (P). Those forming



1. Cross section of a grape cane, much magnified, to show the structure. *ck*, cork. *sb*, soft bast, *h b*, hard bast. *B*, bark, *C*, cambium. *W*, wood. *P*, pith. *M*, medullary ray.

the pith are perfectly inactive and have no practical value in the economy of the plant. The wood of the grape serves as a medium for the passage of large quantities of water or crude sap. In these cells the general tendency of the movement is upward.

The office of the bark and of the corky layer is probably mainly one of protection to the more delicate parts beneath. The cells composing them, excepting the soft bast cells (*sb*), are also inactive, and possess apparently no life. The flow of liquid, if it ever takes place in them, is very limited. The same may also be said of the medullary rays. The use of these woody cells, extending from the pith to the outer bark, seems to be largely mechanical, for they serve as a framework which is designed to give solidity to the stem, and also as a medium of connection between the inner and outer parts of the stem.

One part of the diagram, that marked (*C*), still remains to be discussed, and it is this portion which is of the greatest interest to those

who graft plants. This layer of cells or cambium, as it is called, is that part of the stem which contains the living or growing cells. In the main part of the drawing it is represented simply by two parallel lines. But at the end of these lines to the right the struc-

ture is represented still more highly magnified. It is here seen to be composed of three rows of cells running in a direction parallel to that of the bark. The number of these rows varies at different times of the year, there being many more during the period of active growth.

Office of the cambium.—It will be noticed that the cambium layer separates the wood from the bark. An interesting feature of this layer is that after division the cells next the bark go to the formation of bark, while those nearest the wood form woody fibre, yet the origin of the two is the same. We may suppose the cells of the central row to be divided into halves by a vertical wall. One half will then go to the formation of either wood or of bark, as the case may be, while the other half remains to increase in size and to divide as before. Thus the origin of both the young bark and of the young wood is probably in a single row of cells situated between these two parts of the stem, and it is largely in this layer that active growth in our common woody plants takes place.

From the above it will at once appear that no union will take place between stock and cion unless the living cells, or the cambium layers of the two, are placed in close contact, and no grafting can be successful where these conditions are not complied with. Some plants appear to be more exacting in this respect than others, and the grape, fortunately for the careless vineyardist, is not so particular as are many of our cultivated trees and shrubs. It will undure a certain amount of careless work and still effect a union.

This fact should not encourage poor or hasty workmanship. All tendencies which lessen the chances of success deserve to be studied so that they may be avoided. No sand or dirt should be allowed to rest upon cut surfaces, if it can be helped, until after the parts are placed in position. Such particles would prevent to a greater or less degree the intimate contact of the two surfaces. All cuts should be made as smooth and as straight as possible so that no projection of wood will prevent the two layers from pressing against each other.

It is not essential to success that the cambium layer of the two parts be in contact at every point. Such a result is almost impossible in practical work, and it is especially so in grapes where

large stocks are being worked, for in them the grain is generally considerably twisted. But in order to insure success the layers should come together in at least one point. This will be enough to insure the "taking" of the graft, but the growth may not be very strong, and the union will naturally be rather weak for the first year or two. If the cambium layers are in proper condition and in close contact for a considerable distance, a strong union and a vigorous growth will result.

Condition of cion and stock.—The condition of the cion and of the stock must also be considered, for it is of the greatest importance that these should be in a proper state as regards the comparative activity of the cambium layers. The cion should in all cases be dormant or practically so. If it is not dormant the cambium cells will have become accustomed to a certain supply of sap, and any serious reduction in this supply will be followed by a check which may be fatal. Such a check would take place if an active stem be cut and inserted upon a stock that is unable to supply the accustomed amount of nourishment; or even if the sap of the stock is in active flow the comparatively slight transfer of material which could be made immediately after an operation would be insufficient to supply the demands of the cion.

The stock may be more or less active, however, at the time of the grafting, provided the cion be inactive. A dormant cion requires but little nourishment, and if the stock satisfies these needs that is all that is required. The operations should be successful provided the flow from the stock is not so heavy that the cion will be "drowned out." Such a flow occurs while the first growth in spring is taking place, and cions should be inserted either before it begins or immediately after the most energetic action has ceased.

Seasons for grafting.—Grape grafting may be performed in the fall, early in the spring before the heavy flow of sap begins, or during late spring when the sap is no longer so active; opinions are divided as to which is the best season of the year. If the work is done in the fall, the time for the uniting of the two portions before active growth begins is very long and on this account the chances of success are better. But the danger of accident during the winter must be taken into account to offset this advantage. When the grafts are made below ground, as is commonly

done, there is danger of the cion being heaved out by the frost, or at least of being misplaced to such an extent that no union will take place. Soils which heave the most will be apt to do the most damage. Winter protection is essential to success and where it is given, good results should follow. The protection may consist of burying the cion completely after the graft has been made, or a heavy mulch of some material, as straw, leaves, etc., will answer. Such a covering will prevent the alternate thawing and freezing of the soil, which is sure to result in more or less injury to the graft. A. S. Fuller recommends* grafting grapes "in the fall, after the leaves have fallen, and any time before the ground is frozen, say in October, November or December, varying according to the latitude." His grafts are made below the surface of the soil and are protected very carefully from frost. This is done by placing an inverted flower-pot, sufficiently large for the purpose, over the cion, having the bottom of the pot on a level with the surface of the soil. The excavation is then filled with earth but the bottom of the flower-pot is left uncovered. Then all is covered with about six inches of straw and over this is placed soil to the depth of about eight inches. When so protected, the grafts pass the winter in excellent condition and start off vigorously in the spring.

The majority of those who have had practical experience in the grafting of grapes seem to agree in saying that early spring is the most suitable time for performing the operation, all things considered. The graft should be inserted before the flow of sap has begun, and the first warm days in March are the ones which are well suited to the work in a great many seasons. On the whole, the earlier in spring that the grafts are inserted the better are the chances of success, as more time is allowed for union to take place. Much depends upon the season, but generally March will offer some periods in which the vines can be worked. It is but a short time after the frost is out of the ground before the vines will bleed considerably when cut, so the work must be done before the season becomes far advanced.

The third period in which grapes may be successfully grafted is late in spring, or as soon as the vines have made a growth of

* Fuller, *The Grape Culturist*, 1867, p. 66.

eight or ten inches and the first heavy flow of sap has ceased. The principal objection to this season is the difficulty of obtaining suitable cions. These should be cut while perfectly dormant; they should then be packed in some damp material as sand, sawdust, moss, etc., and placed in as cool a position as can be found. This is done to retard all growth until the cions are inserted. When the grafting is done in the fall or early spring the wood is in suitable condition for use, and it may be cut as wanted. But for late spring grafting the wood must be cut and stored in an ice house if possible, although open ground in some well shaded spot will also answer fairly well.

It will be noticed that in the methods of grafting described in the following pages only those are mentioned in which the cut surfaces of the stock are all below the level of the ground. My experience with grafting grapes above ground* has been such that I cannot recommend it, except for particular purposes. Much better results are obtained when the cions are inserted low enough so that they may be partially or wholly covered by moist earth. The work is then done under certain disadvantages, but the successes are so much greater that they more than make up for the extra trouble.

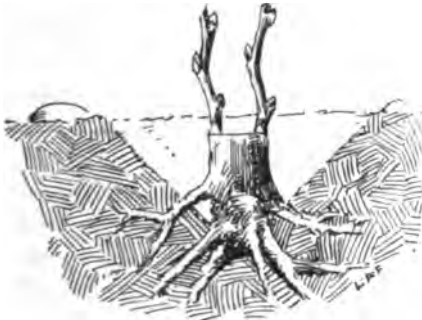
METHODS OF GRAFTING.

On Established Plants.

No. 1. Cleft graft.—This form of graft is generally made by sawing off the vine from three to six inches below the surface of the soil, leaving a stub into which one or two cions may be inserted, as shown in Fig. 2. The saw used should be sharp so that it will work easily and not lacerate the edges of the stub. When much grafting is to be done it might be a matter of economy to have a saw made especially adapted to the purpose. The handle should be on a higher plane than the blade; this allows the free use of the hands above the ground while the blade is below, near the bottom of the excavation made about the stem of the vine. If a common straight saw is used, the stock must be

*For an account of some experiments conducted in 1891 with reference to this point see *Garden and Forest*, v. p. 498.

cut off at an angle or the hole must be made larger, neither result being exactly what is desired. The blade need not be more than six or eight inches long, and only wide enough to give it firmness. The handle, which can be of any convenient



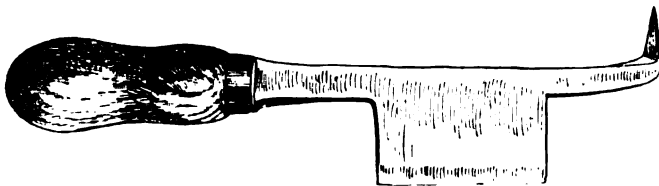
2. *Cleft grafting.*

pattern but large enough to be grasped by both hands, should be attached to a solid bent shank having the part which lowers the block into the excavation from three to four inches in length.

When the stock has been sawed, it is a good plan to smooth the top of the stub, at the places in which the cions are to stand, with

a sharp knife in order to dress those portions of the sawed surface and to show more distinctly the line dividing the bark from the wood.

The next step is to split the stub, leaving the smoothed parts above mentioned at the top of the cleft. This splitting of the stub is not such an easy matter as at first appears. A tool commonly used for this purpose is shown in Fig. 3. It is made very strong so that there will be no danger of its breaking when driven into the stub. A large chisel might answer the same pur-



3. *Grafting knife for splitting stubs.*

pose. The cutting edges should be sharp to prevent unnecessary tearing of the cells. The grain of grape wood is by no means very straight and some varieties seem to have a peculiarly twisted wood. In such cases a keen edge upon the tool is of great value. It has been recommended to use a fine saw for making a cleft to

receive the cions ; in many cases this advice is well worth following for it is practically impossible in some instances to split a stub in such a manner that a cion will have much chance of growing.

When the stub has been split or sawed to a depth of about two inches it is then ready to receive the cions. These should be prepared as shown in Fig. 4. They should carry at least two



4. *Cion.*

buds, and short-jointed wood may carry three. The cuts which form the lower end of the cion into a wedge should begin a little below and on each side of the lower bud. The wood should be cut so that the edge opposite the bud shall be thinner than the part under it, as is shown in the illustration. These cions may be prepared in this manner before taking them to the field, but care must be taken that the cut surfaces do not become dry. This may be prevented by packing them in some clean material as moss or moistened cloth. When all is ready for the insertion, the wedge which projects at the end of the grafting knife, Fig. 3, is driven into the central portion of the cleft until the space is large enough to receive the cions. These are then carefully inserted, not in a direction parallel to the central axis of the stub, but at a slight angle with it, allowing the tops of the cions to lean a trifle away from the stub and from each other. The reason for this inclination is to make sure that the cambium layers of cion and stock cross at one point at least. The greater the angle of the cion the shorter will be this place of contact ; therefore, care must be taken that the cions diverge but slightly. When both cions are in position, the lower bud, having been placed on the outside, the wedge is carefully withdrawn. As the cleft in the stub closes, pressure is brought to bear upon the grafts ; but since these were cut so that the portion under the lower bud is thicker than the part opposite to it, the pressure is greater at the outer side of the cion. This is where it is wanted, for the cambium layers are brought into very close contact and if the work has been well done success is practically assured. In case of large stubs, the pressure in the cleft may be severe enough

to injure the graft. When the cion is being squeezed so that its form is altered it is well to insert a wooden wedge in the cleft to relieve this excessive pressure.

All that now remains to be done is to fill the cavity about the stub with earth, and the cion should also be buried so that only about an inch, or the part above the upper bud, remains uncovered. The soil should be firmed slightly to prevent it from drying out, and the operation is finished. Wax is sometimes used to cover the cut surfaces of both cion and stock, but I have never been able to see that any advantage was obtained from its use that the earth did not grant equally well. Some have gone so far as to say that its use is positively injurious, so when the grafts are placed below the surface of the soil the use of wax is not recommended.

The growth made the first season by such grafts is frequently very large, and enough wood is formed and a sufficiently strong union made to support nearly a full crop of grapes the next year. If the operation is well done, therefore, only one season is entirely lost and but a small part of the crop of the second.

No. 2. Cleft graft on a partially severed vine.—This form of graft differs from the preceding by not having the vine completely cut off. A horizontal cut is made only about half way through the stock, and then another cut is made, beginning from one to three inches above the horizontal cut, and sawing inwards and downwards so that a wedge-shaped piece is removed from one side of the stem. The length of the downward cut should be about one and a half times as long as the horizontal cut, in order to allow the cleft to be made more easily. The manner of inserting the cions is identical with that already described.

The advantage of this form of graft is that if the cions die the original vine is not lost, but will continue to bear. The yield may be smaller, yet some crop is harvested whether the cions die or live. In the latter case the old vine is pinched backed so as to throw more sap into the grafts. The second year the old vine is reduced still more and at the end of the year may be cut away entirely, thus allowing the cions to take its place. In this manner but a comparatively small loss in yield is sustained.

No. 3. Crown graft by inlaying.—Figure 5 represents the stock prepared for this form of graft. The stock is cut as for cleft grafting. In place of splitting the stub, two V-shaped grooves are made



5. *Crown grafting by inlaying.*

on opposite sides of it. These grooves are made by means of an instrument especially designed for the purpose. It is shown in fig. 6. The tip cuts out the triangular part as shown in the illustration. In the blade itself is a part which is bent at the same angles as the parts forming the tip. This indented portion of the blade is used for cutting away the end of the cion, and with very little practice an almost perfect fit of the two parts can be made. The two cions are then placed upon the stock and are firmly tied there. The tying material should be of such a nature that it will decay before there is any danger of strangling the cions. Raphia does very

well, as does also bast. I have also used No. 18 knitting cotton, soaked in boiling grafting wax, with entire satisfaction. The ligatures should be made as tight as possible.

Although this method of grafting is not so commonly used as others, it still possesses some decided advantages. It is a much simpler and more satisfactory method than cleft grafting in very curly wood. The tying is a slow process, and for straight-grained wood the cleft graft is to be preferred. It is also open to the objection of requiring



6. *Grafting knife for inlaying.*

the shoots to be staked or tied to some support, for the wind is apt to break the point of union more easily than with other methods. A good union admits of a very strong growth, and if the above precautions are kept in mind the vines will equal those produced by either of the preceding methods.

No. 4. Cutting graft.—Figure 5 also shows a cion prepared

for another graft. The only difference between this and the preceding is that the cion is made very long. One side near the top is cut in the form of a wedge which fits snugly into the V-shaped cut in the side of the stock. The lower part of the cion projects downward and outward for ten or fifteen inches. This lower portion also takes root and under favorable circumstances an enormous growth can be made the first year. One plant in the vineyard of J. W. Corbett, near Watkins, N.Y., upon which a Niagara cion had been inserted in this manner, made a total growth the first season of



7. *The first season's growth of a cutting graft.*

fully seventy-five feet (Fig. 7) and the next year it bore about fifty clusters of grapes. The stock was Red Wyoming, six years old. Figure 8 shows such a union one year from grafting. This is a more certain form of graft than No. 3, and although more tedious is still to be recommended as one of the safest methods. The cion is the portion running down the left side of the picture.

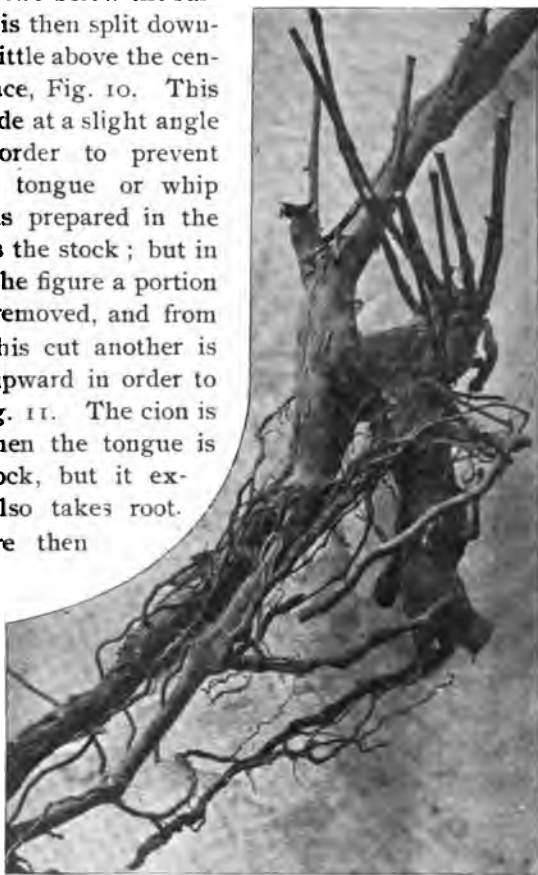
The sprouts which have started from the stub should be kept down in this as well as in other forms of grafting, but they appear to be particularly abundant when this method is followed.

No. 5. Modified tongue graft.—Figure 9 represents a form of grafting which is quite common in Italy. The stock is cut off at an angle an inch or two below the surface of the soil and is then split downward, beginning a little above the center of the cut surface, Fig. 10. This downward cut is made at a slight angle to the grain in order to prevent splitting. In true tongue or whip grafting the cion is prepared in the same manner as the stock; but in the graft shown in the figure a portion of the bark is first removed, and from the lower end of this cut another is made inward and upward in order to form the tongue, Fig. 11. The cion is not cut in two when the tongue is made, as is the stock, but it extends below and also takes root.

Cion and stock are then

united as shown in Fig. 9, care being taken to have the cambium layers in contact on one side. When cuttings or parts of equal diameters are grafted by the tongue graft, the layers on both sides may be

placed together. The tying of grafts is advisable when small wood is used, but large stocks, when cut below the ground, scarcely require this precaution. When the operation is finished, the soil is heaped up as in cleft grafting.



8. Cutting-graft one year old.

In California* the tongue graft has gained considerable favor for large as well as for small stocks. In case the stocks are large, they are pared down so that the part upon which the cion is inserted is not much wider than the cion itself. When the two parts are in position, the graft is firmly tied with strips of common calico about an inch wide and ten inches long. The estimate

of the cost of the operation is given at three cents per vine, this including the second grafting of those which failed to grow the first time.



9. *Modified tongue graft.*



10. *Modified tongue graft, prepared stock.*

No. 6. Side graft.—This method possesses an important advantage, already spoken of under No. 2. The stock does not need to be cut off in order to insert the cion. A cut is first made inward and downward in one side of the stock

at the same distance under the surface of the soil as for the other methods named. For making this side cut, a tool shown in Fig. 13 is very useful. The shaft is bent so that it can be easily held, and the lower end is made comparatively thin so that the wood will not sliver much when the cutting edge is driven in. An ordinary chisel if well sharpened may answer the same purpose, but not so well. The tool should be driven in from one to one and a half inches.



11. *Modified tongue graft, prepared cion.*

* Leonard Coates, Report of the Sixth Annual State Viticultural Convention, 1888, p. 50.

The cion for this graft is easily made. The lower end is cut in the form of a simple wedge, and it is then pushed into the cut in the side of the stock until all the cut surfaces of the cion are covered by the lip of wood on the stock. Figure 12 shows the manner of insertion; it represents the upper end of the lip as being removed, but this is not necessary. After the cion is inserted, taking care to have the cambium layers as nearly in contact as possible, the stock is firmly bound. The cavity is then filled with earth and the operation is finished. As the cion grows, the old vine should be pinched back so that the nourishment may go to the formation of the desired top.

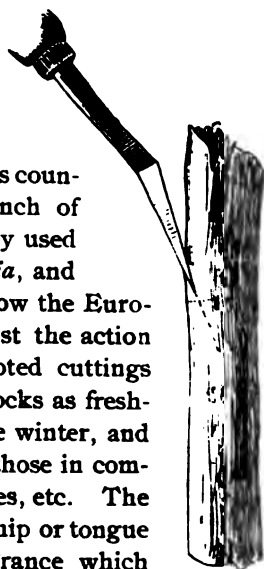


On Cuttings.

No. 7.—Figure 14 shows a rooted cutting on which has been grafted a cion by means of the cleft graft. It represents a class of grafts which, though as yet of little

practical importance in this country, is in Europe a very important branch of grape propagation. The stock commonly used there is the strong growing *Vitis riparia*, and the operation is performed in order to grow the European varieties upon roots which will resist the action of the root louse, or phylloxera. Rooted cuttings are perhaps not so commonly used for stocks as freshly cut wood. The grafting is done in the winter, and the methods followed are very similar to those in common use here for the root grafting of apples, etc. The splice graft is often used, as well as the whip or tongue graft. Machines have been made in France which sort the cions and the stocks so that only those having equal diameter are united. This increases the chances for a successful union.

After the two parts are placed in position, they are



13. Tool for making incision for side graft.

firmly tied with waxed twine and packed in damp material until spring. They are then set out in nursery rows and allowed to grow one season. The following year they are set in vineyards, although in some cases this is done directly, instead of putting them first in the nursery. The grafts are planted so that the point of union between cion and stock shall be on a level with, or a trifle below the surface of the soil. The earth is then heaped around the cion leaving only the upper bud exposed.

This method of grafting may become of value in this country for the purpose of having weak growing varieties upon vigorous roots. The field is so new that one can scarcely predict what will be the results which may follow from grafting one variety of grape upon another.

Figure 15 represents a successful graft seven years old when photographed. The operation was performed by B. P. Olin, North Hector, N. Y. He inserted a cion of Brighton upon a four-year-old Agawam stock, and so perfect was the union that not an external trace remains to show where the two parts are joined. The point of union is on a line directly between (a) and (b), as could be seen when the stock was cut. Under such favorable circumstances there is no reason to suppose that grafted vines are not as long lived as those upon their own roots, provided suitable varieties are selected.



14 Rooted cutting cleft grafted.

No. 8. A peculiar method which has been employed in grafting cuttings is shown in fig. 16.* The description is here given in full:

"The following method of propagation has done well where I had a new variety that I wished to multiply rapidly. In taking up vines in the fall, when clipping back the roots, I save bits of them about a quarter of an inch in diameter, and keep them in damp sand until needed. In February or March I cut these roots in pieces two inches long, using a piece to each graft, as in apple

* Samuel Miller, *American Gardening*, September, 1892, p. 535.

root grafting, but instead of that method cut the upper end of the



15. *A successful graft seven years old.*

piece of root wedge-shaped and inserted it in the lower part of the graft as shown in the illustration (Fig. 16). If the wood is long jointed I use one eye to the graft; if short, two eyes. Tie the grafts firmly with waxed thread. The root gives the graft-eye a start, and by fall I have a row of them average three feet in growth.

"These grafts can be placed upright in boxes of sandy soil and left there until they have started to grow. If you can give them a little bottom heat it will be a great help. Accustom them to plenty of air and sunshine before setting them

out in the open ground, plant them late in the afternoon, and

shade them for a few days. The grafts soon callus at the lower ends and emit roots of their own."

Although the above graft appears to be very successful, the work and care required for its execution will probably prevent its general use. It might properly be called an inserted side graft, and it is probable that if the grafts are made early enough in the winter, union would take place before active growth begins, and less care be necessary to insure success.

SUMMARY.

1. The living or growing cells in the stem of the grape are largely in the cambium layer. Page 460.

2. A union between cion and stock will not take place unless the cambium layers are in close contact. Page 461.

3. The grape is not difficult to graft, but the operations must be carefully performed. Page 461.

4. The cion should be dormant or practically so at the time of insertion. Page 462.

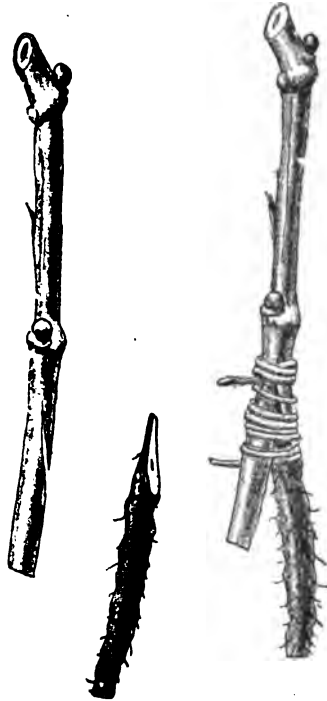
5. The stock may be dormant, or the sap may be active, but the heavy flow of sap which occurs in spring should be avoided. Page 462.

6. Grapes may be grafted in the fall, early spring, or late spring. Page 462.

7. When the work is done in the fall or winter, protection must be given in this latitude. Page 463.

8. Early spring is on the whole the best time for grafting grapes, and the earlier it is done the better. Page 463.

9. Cions inserted late in the spring will unite with the stock provided they have been kept dormant. Page 464.



16. *Inverted side graft for cuttings.*

10. Grape grafting will be followed by better results if the cions are inserted below the surface of the ground. Page 465.

11. Cleft grafting is the most common and perhaps the most successful form of graft to use, but it necessitates the entire removal of the top. Page 464.

12. Cleft grafting on a partially severed vine does not require the complete removal of the top, and under similar conditions offers nearly as good chances of success as when the ordinary cleft graft is used. Page 467.

13. Crown grafting by inlaying is a more difficult operation than cleft grafting, but it offers the advantage of being preferable when the wood of the stock is curly, and does not split readily. Page 468.

14. Cutting grafting is a more difficult and tedious method, but is followed, when well performed, by exceptionally vigorous growth. Page 468.

15. Tongue grafting, as practiced by the Italians or by the vineyardists of California, gives excellent results both upon large and small stocks. Page 470.

16. Tongue grafting is one of the safest methods to use, but it is not always the easiest to perform. Page 470.

17. Side grafting is one of the best forms of inserting cions. It is easily performed and gives satisfactory results. The vine does not need to be severed, and the same stock can be repeatedly used. Page 471.

18. The grafting of grape cuttings, whether rooted or not, is carried on in this country to a very limited extent, but it may become an important operation in the future. Page 472.

19. The tongue graft is probably the best form to use for grafting cuttings, but other methods may be employed with success. Page 472.

20. A vine properly grafted is probably as long lived as one upon its own roots, if suitable stocks are selected. Page 473.

E. G. LODEMAN.

30.07

17
-526

NOV 17 1894

Bulletin 78.

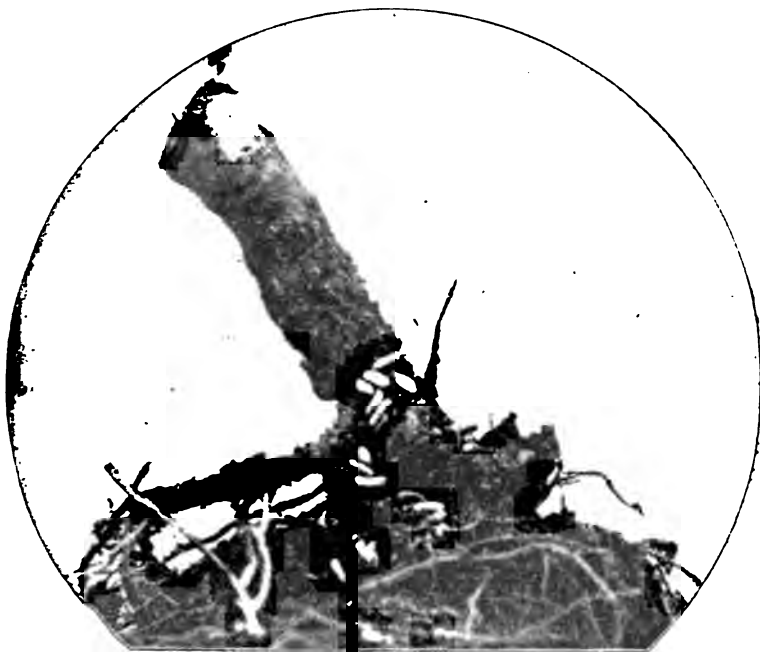
November, 1894.

**Cornell University Agricultural Experiment Station.
ENTOMOLOGICAL DIVISION.**

The Cabbage Root Maggot

WITH NOTES ON

The Onion Maggot and Allied Insects.



By M. V. SLINGERLAND.

**PUBLISHED BY THE UNIVERSITY,
ITHACA, N. Y.
1894.**

ORGANIZATION.

BOARD OF CONTROL:

THE TRUSTEES OF THE UNIVERSITY.

STATION COUNCIL.

President, JACOB GOULD SCHURMAN.

Hon. A. D. WHITE,	-	-	-	-	Trustee of the University.
Hon. JOHN B. DUTCHER,	-	-	-	-	President State Agricultural Society.
Professor I. P. ROBERTS,	-	-	-	-	Agriculture.
Professor G. C. CALDWELL,	-	-	-	-	Chemistry.
Professor JAMES LAW,	-	-	-	-	Veterinary Science.
Professor A. N. PRENTISS,	-	-	-	-	Botany.
Professor J. H. COMSTOCK,	-	-	-	-	Entomology.
Professor L. H. BAILEY,	-	-	-	-	Horticulture.
Professor H. H. WING,	-	-	-	-	Dairy Husbandry.
Professor G. F. ATKINSON,	-	-	-	-	Cryptogamic Botany.

OFFICERS OF THE STATION.

I. P. ROBERTS,	-	-	-	-	Director.
E. L. WILLIAMS,	-	-	-	-	Treasurer.
H. W. SMITH,	-	-	-	-	Clerk.

ASSISTANTS.

M. V. SLINGERLAND,	-	-	-	-	Entomology.
GEO. C. WATSON,	-	-	-	-	Agriculture.
G. W. CAVANAUGH,	-	-	-	-	Chemistry.
E. G. LODEMAN,	-	-	-	-	Horticulture.
MICHAEL BARKER,	-	-	-	-	Horticulture.

Office of the Director, 20 Morrill Hall.

Those desiring this Bulletin sent to friends will please send us the names of the parties.

BULLETINS OF 1894.

62. The Japanese Plums in North America.
63. Co-operative Test of Sugar Beets.
64. On Certain Grass-Eating Insects.
65. Tuberculosis in Relation to Animal Industry and Public Health.
66. Test of Cream Separators.
67. Some Recent Chinese Vegetables.
68. The Cultivated Poplars.
69. Hints on the Planting of Orchards.
70. The Native Dwarf Cherries.
71. Apricot Growing in Western New York.
72. The Cultivation of Orchards.
73. Leaf Curl and Plum Pockets.
74. Impressions of the Peach Industry in Western New York.
75. Peach Yellows.
76. Some Grape Troubles of Western New York.
77. The Grafting of Grapes.
78. The Cabbage Root Maggot with notes on the Onion Maggot and Allied Insects.

THE CABBAGE ROOT MAGGOT.

Phorbia brassicae Bouché.

Order DIPTERA ; family ANTHOMYIIDAE.

For many years, growers of cabbages and cauliflowers have recognized in this pest a most formidable enemy of these desirable vegetables. Peter Henderson has said that "tens of thousands of acres of cabbages and cauliflowers have been utterly ruined in a single season by this insect." And the destruction still continues, seemingly unabated.

Every year reports of the ravages of this pest have reached us from different parts of the State. But it was not until the spring of the present year that a favorable opportunity occurred to study the insect, especially with a view to finding some effective preventive or destructive method of combating it. Then, at the urgent request of several cabbage growers on Long Island, the writer began work on the pest. In March, several of the leading gardeners on the Island were visited, and all willingly offered their services, their cabbage fields, and a sure crop of "maggots" for experimentation.* Many gardeners had given up trying to grow early cabbages and cauliflowers solely on account of this pest. A very favorable field for operations was found at Mattituck, near the eastern end of the Island and in the center of one of the greatest cabbage seed growing regions in the world. In April and May, two subsequent trips were made to Mattituck for the purpose of applying preventive and destructive substances and to note their effects. On the last trip, thousands of the "maggots" were secured and brought to the insectary for further experimentation with destructive substances, and for the study of their life-history.

*The writer is indebted to Messrs. Henry Hicks, C. L. Allen, P. H. Scudder, and J. M. Lupton for much information and many kindnesses. To Messrs. T. E. Reeve and Son, are we especially indebted for the use of their cabbage field for experiments, and for their careful services and important information while the experiments were in progress.

This six months' study of the insect has revealed many new facts regarding its habits, life-history, etc., and yet there are many questions of considerable importance still unsolved; and especially is there need of more careful experiments in combating it. However, we feel that enough has been accomplished to warrant the preparation of this bulletin. It has been made as complete as possible; all accessible records have been searched in order that this record may include what has heretofore been known of the pest and the methods recommended to combat it. In other words, the aim has been to bring together the multitudinous scattered facts recorded about this pest and combine them with the new facts revealed by our observations, thus making them all readily accessible to gardeners and others in a single publication.

THE DISTRIBUTION AND PAST HISTORY OF THE PEST.

Like its food-plants, this insect is doubtless of European origin; although it was seen and named in this country only a few years after its first description appeared in Germany, over 60 years ago.

It was considered a serious pest as early as 1833; Bouché then wrote: "It often destroys whole cabbage fields." That it has continued to be a pest in Germany is shown by the fact that it is discussed by all later German writers on garden insects; and collectors have recently reported it common in that country. In 1835, it was found in France, but seems never to have attracted much attention as a pest there. It has been recognized as a pest in England since 1840; possibly it was known there by Major (Treatise on Insects) in 1829 as the cauliflower fly. There are many discussions of the pest in later English publications. Nearly every year during the past decade the pest has been reported by Miss Ormerod as doing much injury in various parts of England. In 1872, it is recorded as doing considerable damage to radishes in the Netherlands. Thus it seems to have been recognized as a serious pest since the early part of the present century in various parts of Europe, especially in Germany and in England.

It was first recorded in the United States by Dr. Harris who gave it a name in 1835, and described it in 1841 from Massachusetts. Dr. Fitch, in 1867, said it was so destructive in our State in 1856 and 1857 that in many neighborhoods it was impossible to obtain plants for setting out. In 1857, the pest was being fought in Maryland. Prof. Prentiss found the "maggots" doing much damage in Michigan in 1867. Trimble records it destructive to his radishes in New Jersey in 1870. In 1875, Dr. Packard said he had known

the pest in Maine for over twenty years. A gentleman in Pennsylvania had nearly four acres of cabbages destroyed in 1877; and the next year the pest was very destructive in Luzerne County, in the same State. In 1885, Fletcher reported that the pest had that year destroyed from 25 to 75 per cent. of the cauliflowers in Canada; it occurred in all of the Provinces from Nova Scotia to Vancouver's Island (it must have been present in Canada for many years previous to have attained this wide range). A radish grower reported the pest from Colorado in 1886; Cockerell recorded it from the same State in 1889. In 1887, turnips suffered from the "maggots" in Vermont; in the same year the insect was also reported from South Carolina and Georgia. In 1889, experiments were tried against the pest in Alabama and in the State of Washington. It was injurious in Mississippi and Wisconsin in 1892. The following year, 1893, Alwood reported it very destructive in Virginia. This year it has been recorded as injurious in Oregon.

Thus the pest was introduced into this country from Europe early in the present century, perhaps first appearing in Massachusetts, from whence it gradually spread north, west, and south into the neighboring States. In about 25 years it had reached Maine on the north, Maryland on the south, and Michigan on the west. In 20 years more it had reached the Pacific Ocean, entered Colorado, and passed through South Carolina into Alabama. In a little more than half a century it had thus spread over the greater portion of the United States and Canada. Doubtless it is now present in injurious numbers in every State where its food-plants are grown to any extent.

Whenever the pest obtains a foot-hold, it usually appears in alarming numbers year after year if its food-plants continue to be grown in the neighborhood. In England it has been very destructive almost every year since 1880. In the United States, the gardeners in this State (especially in the neighborhood of New York City, over the line in New Jersey and throughout Long Island) and in Michigan have suffered severely from the pest almost every year, as the records show, for the past 25 years. Many market gardeners on Long Island have abandoned the growing of early cabbages, cauliflowers, and radishes on account of this formidable pest. In 1897, Peter Henderson said: "tens of thousands of acres the past season have been, of both cauliflower and cabbage, utterly ruined by maggots." In Canada the pest has been especially injurious in 1885, 1887, 1890, 1892, and 1893; in 1892 it was considered the most destructive insect of the year.

From this somewhat detailed account of the past history and distribution of the Cabbage Root Maggot, we may draw this general conclusion: that it is common and often does much damage throughout Europe, from whence it was introduced early in the

present century into the United States and Canada where it now occurs in nearly every State and Province in sufficient numbers to annually destroy thousands of acres of Cabbages, Cauliflowers, Radishes, and Turnips, thus causing a loss of thousands of dollars every year to the gardeners of America.

ITS FOOD-PLANTS.

The name Cabbage Root Maggot, by which this pest is most commonly known, would indicate that its food-plant was the cabbage, *Brassica oleracea*; this species now embraces the kales or borecoles, collards, brussel's sprouts, cauliflower, and broccoli. However, we find that the insect has quite a range of food-plants, but apparently confines itself chiefly to the *Cruciferae* or Mustard Family.

When it was described in 1833, it was said to live in the roots and stems of the different kinds of cabbages; the next year the same author described it, under another name, as living in radishes, *Raphanus sativus*. More recently Taschenberg and Schmidt-Göbel have added the following food-plants of the insect in Germany: *Raphanus radiola*, turnips, and stocks (*Matthiola*). In England, the pest has been recorded, not always under the same name, however, on cabbage, including the other forms of this species, on turnips (*B. rapa*), and on swede turnips (*B. campestris*). Miss Ormerod says that Mr. Meade reared the insect in 1882 "from maggots found in earth round partly-decayed Clover roots."* The same author believes that the maggots feed on the stable manure used on cabbage fields. However, no definite observations are given in support of this opinion. In 1833, Bouché said: "Avoiding the use of new dung is likewise of no avail as these root-devouring larvae are not annoyed by the want of it; nor are they conveyed in it into the field, as some believe." There is but little doubt that where large quantities of stable manure are used the pest sometimes appears in the greatest numbers. Possibly the smell of the manure may attract the insect, and certainly the stable manure would lighten up heavy soils, thus enabling the maggots to work to a better advantage and do more damage; these seem the more probable explanations of the presence of the pest in increased numbers where stable manure is used, and not because the manure furnishes a further supply of food for the maggots.

*I find no reference to this in Mr. Meade's writings. Perhaps some roots of a Cruciferous weed were overlooked among the Clover roots; these, as will be shown later, would account for the presence of the insect. This is an important point in the habits of this pest and should be further investigated.

In this country the insect first attracted attention as a radish pest nearly 60 years ago; Dr. Harris then thought it different from its European congeners and named it as a new species*. In 1867, Dr. Fitch recorded the insect as infecting cabbages, cauliflowers, turnips, rutabagas, and radishes. Although he discussed the Cabbage-fly and the Radish-fly under different names, yet he was unable to discover any differences between them.

In 1872, Mr. Brill, a market gardener, recorded that he "believed the Cabbage Maggot and Radish Maggot to be one and the same." Five years later, Dr. Riley said: "The species affecting the Cabbage, the Onion, the Radish, etc., have received different names but several of them doubtless constitute but one species."

During the next decade, all writers seem to have considered the Cabbage-maggot and Radish-maggots as separate insects. In 1887, however, Prof. Cook gave a detailed account of some very important experiments to prove his belief that the insects which attack the onion, the cabbage, and the radish are but trimorphic forms of one species. His experiments quite conclusively show the identity of the cabbage and radish maggots; but the evidence is not sufficient to support the conclusion that the Onion and Cabbage-maggots are the same.†

The next year Prof. Cook said: "I am more and more convinced that the insects of the genus *Anthomyia*, working on onions, cabbages, and radishes are one and the same species. This year beans have been seriously injured again by a similar, I believe the same species." However, this Bean Root Maggot appeared in Canada in 1885, and Mr. Jack (17th Rept. Ont. Ent. Soc., p. 17) shows that it is the Fringed Anthomyiid (*Phorbia fusciceps* Zett.), and not the Cabbage Root Maggot.

Recently, Mr. Fletcher sent me considerable material reared in Canada from Cabbages and Turnips (British Columbia). Only one species, the Cabbage Root Maggot, was represented.

In 1882, Dr. Lintner recorded this pest in a new role, not suspecting, however, that it was the common Cabbage Root Maggot. He bred the insect

*In the notes on the bibliography in the latter part of this bulletin, I have given my reasons, from the systematist's standpoint, for considering Dr. Harris' Radish-maggot the same as the Cabbage Root Maggot.

†Through the kindness of Prof. Davis, I have been able to examine some of the material bred by Prof. Cook in 1887. I saw specimens of flies bred from radishes, and flies and maggots reared on cabbages; all were typical *Phorbia brassicae*, Bouché, the Cabbage Root Maggot, while the flies and maggots bred from onions were all typical *Phorbia ceparum*, the Onion Maggot. There is another Anthomyiid which has been bred from onions, namely, the Fringed Anthomyiid, *Phorbia fusciceps* Zett., that quite possibly may have been present with the Onion and the Cabbage Root Maggots in Prof. Cook's experiment. Dr. Riley has bred this species from cabbages and radishes, and to a casual observer it would form a good connecting link between the large indistinctly marked Onion Fly and the Cabbage Fly. I have not seen specimens of Prof. Cook's Raspberry Maggot, but Mr. Fletcher sent me one wing and a puparium of an Anthomyiid which he bred from raspberry canes; the wing was similar to that of the Cabbage Fly, but the puparium was distinctly different from that of any Anthomyiid with which I am acquainted. Thus it is very doubtful if the raspberry should be recorded among the food-plants of the Cabbage Root Maggot.

from maggots which were mining in the leaves of beets. This is the only well-authenticated instance of the pest attacking other than Cruciferous plants. This leaf-mining habit of the insect seems not so improbable, however, when it is known that in 1878, Dr. Riley found the maggots burrowing in the stout mid-ribs of cabbage leaves in the summer; and Mr. Fletcher has recorded, in 1891, the pest as mining in the mid-ribs and boring through the heads of winter cabbages in storehouses.

Breeding experiments here at the insectary have developed further confirmatory evidence in support of some of the conclusions to be drawn from the above account of the recorded food-plants of this pest. And these experiments have also revealed several new food-plants of the insect, which will throw new light on its habits and life-history; and which are of considerable importance in connection with the methods to be used in combating the pest.

In 1891, maggots ruined a field of turnips at Ithaca; the insect was bred at the time, and it proves to be the Cabbage Root Maggot. This year several turnips and radishes were growing in an exposed bed in the insectary; and some of them were found to be attacked by maggots which produced the Cabbage-fly. The pest has also been bred, in the insectary, from the buried stems of seed cabbage.

Thus these breeding experiments, the evidence of other observers, especially of Dr. Fitch and Prof. Cook recorded above, and the identity of all the Cabbage and the Radish-maggots examined from various parts of the country seem, to the writer, sufficient proof that *the* Cabbage and *the* Radish Maggot are the same insect.*

After learning that it is the universal testimony of cabbage and radish growers that the maggots do but little damage to late crops of these vegetables, the question at once occurred to us, has the pest other, as yet unsuspected, wild food-plants? Naturally our attention was turned to the Mustard-like weeds which are usually to be found in abundance in every garden or cultivated field and along the road-sides. Therefore, in the latter part of May, plants of the well-known Shepherd's Purse (*Capsella bursa-pastoris*), and of the Common Winter Cress or Yellow Rocket (*Barbarea vulgaris*) were transplanted from the field to cages in the insectary; and 100 maggots, brought from Long Island, were put about the base of each plant. Three weeks later the cages were examined. The maggots had eaten freely of the roots of the *Barbarea*; but the roots of the Shepherd's Purse showed only slight indications of having been eaten, and many of the maggots had failed to develop.

* I say "*the* Cabbage and *the* Radish Maggot" because two other Anthomyiids, *A. radicum* the Root Maggot, and *P. fusciceps*, the Fringed Anthomyiid, are recorded as feeding on these vegetables; but I believe the latter rarely does, and the former not nearly so commonly as does *P. brassicae*.

This experiment suggested an examination of plants in the field. About June 15, many plants of the Shepherd's Purse, the Common Winter Cress, and Hedge Mustard (*Sisymbrium officinale*) were examined in various localities near the insectary. The result was surprising. Scarcely a plant of the last two weeds had not had their roots considerably damaged by maggots; but not a plant of the Shepherd's Purse seemed to have been attacked by them. That these maggots found at the roots of these weeds were the Cabbage Root Maggot was shown by breeding the insect in cages on the weeds, and also by transferring maggots from the weeds to cabbage plants and producing the typical Cabbage-fly in both cases.*

These experiments thus show that the Cabbage Root Maggot has several wild food-plants to which it can and probably does resort in case none of its, perhaps preferable, cultivated food-plants are grown in the locality. Doubtless the pest also breeds upon the roots of several other common species of the Mustard-like weeds, some of which may be more common in certain localities than either of the two upon which we have found the maggots common about Ithaca. Probably the natural food-plants of this pest are some of the Mustard-like weeds, many of which have been introduced here from Europe; and one may thus expect to find the Cabbage Root Maggot wherever these weeds occur.

It is remarkable that no one seems to have discovered these maggots on these weeds, nor have suspected that the Cabbage Root Maggot might breed upon such plants. That they do thus feed upon weeds is in itself an important fact, but we believe it will serve to explain other more important points in the life history of the pest which have heretofore puzzled observers.

To briefly summarize this detailed account of the food-plants of this pest, we may say that it has been recorded in Europe on the cabbage (including the cauliflower, borecoles, etc.), the radish (*Raphanus sativus* and *radiola*), the turnip (*Brassica rapa*), the ruta бага and swedes (*Brassica campestris*), and on stocks (*Matthiola*); the reported feeding on clover roots and manure needs further confirmation. In this country the Cabbage Root Maggot feeds upon most of the above plants and on at least two common Mustard-like weeds, the Common Winter Cress (*Barbarea vulgaris*), and the Hedge Mustard (*Sisymbrium officinale*); the

* One of the Fringed Anthomyiids (*Phorbia fusciceps*) was bred from a maggot found on the roots of the Hedge Mustard (*S. officinale*).

maggots infesting onions, beans, and raspberry canes are different insects, distinct from each other and from the Cabbage Root Maggot.

INDICATIONS OF THE PRESENCE OF THE PEST.

Some gardeners who are familiar with the different stages of the insect, can often tell, by watching their plants closely about May 1, whether the pest is laying eggs or not, and thus do not have to wait until its presence is indicated through its effect on the plant. It is one of the chief aims of this bulletin to thus render the different stages of this insect familiar, by means of descriptions and illustrations, so that all observing gardeners can recognize its presence in their cabbage fields and radish beds, before the maggots fairly begin their ruinous work. Unfortunately, however, many gardeners recognize the insect only in its maggot stage. But as the pest is then out of sight in the soil, its presence is often not suspected until much damage has been done. Sometimes the pest gets at work early enough in the spring to catch the tender plants in exposed seed beds. Here the small plants quickly succumb to the attacks of the maggots; for a few days the infested plants may have a weak, sickly appearance, when suddenly, in a day's time, they will wilt down and die. Sometimes the seed beds of late varieties suffer in the same way in June or July. Young radish or turnip plants succumb in a similar manner.

Usually, however, the maggots first make their presence felt on the plants after they have been set in the field about two or three weeks. This year, on Long Island, the plants began to show the effects of the maggot about May 15; the time will vary with the season, locality, and latitude.

If cabbage plants once get thoroughly established before the maggots attack them, unless the maggots occur in considerable numbers, the plant may show scarcely any indications of the presence of the pest. This is due to the fact that the plants of the cabbage tribe are all gross feeders; and thus always require a very rich soil from which they quickly repair injuries to their root-system, especially if the soil is kept moist by rains or otherwise. Gardeners understand this and often hill up their plants, which then soon send out new roots farther up on the buried stem.* This power of the plant to overcome the ravages of a few maggots is an important point, especially in connection with some of the remedies recommended for the pest. In radishes and turnips, however, a single maggot may render the root unfit for food without otherwise materially injuring the plant; quite a number of maggots might attain their growth in the large fleshy root of these plants without indicating their presence by any very noticeable change in the vis-

* Mr. Reeve of Mattituck said he had often saved many of his cabbage plants, after they had been nearly ruined by the maggots, by carefully hilling up around the stems and watering them well. New roots would soon be put out, and he had produced many good, but later, heads of cabbage in this way.

ible portion of the plant. Thus in the case of these crops, unless the maggots occur in large numbers, the presence of the pest may not be discovered in a well-established root until it is pulled up.

Therefore, how soon the plant will soon show the presence of the pest will depend upon its size, the number of maggots at work, the amount of quickly available fertility in the soil with which to repair damages, and the conditions of the weather, as amount of rainfall, etc.

Usually the first indications of the presence of the pest on plants of the cabbage tribe is a noticeable checking of their growth, and a tendency of the leaves to wilt badly under a hot sun. The leaves soon take on a sickly bluish color, a few days later the whole plant wilts, often topples over, and soon dies. If one of these plants be pulled up, the stem and roots often present the appearance shown in the illustration on the front of this bulletin and in figure 1, both of which are from photographs of specimens pulled up in a Long Island garden. It is not an unusual thing for a gardener to suddenly find on some hot day a majority of his plants of cabbages or cauliflowers thus wilted and toppled over where the maggots have been very numerous. It is a sad plight when one realizes how much money and labor has been spent to bring the plants to that stage; and what is still worse, they are then often beyond help even if the maggots were killed at once. So that gardeners should familiarize themselves with the other stages of the insect and when to look for it, thus making it unnecessary to wait until the destructive period is reached before being able to tell whether the pest is present or not, so as to check it if necessary before the crop is ruined.



FIG. 1.—Stems and roots of cabbage plants that had succumbed to the attacks of the maggot; one-half natural size.

In brief, the presence of the pest, where it occurs in considerable numbers, is indicated by a checking of the growth of the plant, a tendency to wilt badly under a hot sun, and a sickly bluish cast to the foliage.

THE INSECT'S APPEARANCE.

The larva or maggot.—Everyone who has had any experience with this pest is familiar with it in this—the maggot or larval stage. And yet, we have not been able to find an illustration by which the maggot could be definitely recognized. The only observers who have given us definite descriptions of this form of the pest are Bouché (who gave the insect its name in 1833), and Dr. Fitch (in 1867); all other descriptions are either inadequate or evidently compiled from these authors.

The maggots, from their birth, are similar in form to the full grown one represented in figure 2, and are always footless and of a shining white color, sometimes tinged with yellowish. The body is cylindrical, tapering to the cephalic end where the two strong, black, parallel, curved, rasping jaws project downward; these hooks are connected with an internal blackish framework which is indistinctly visible through the skin of the maggot (Fig. 9). The caudal end of the body ends bluntly, appearing as though cut off obliquely downward and backward.



FIG. 1.—*The Cabbage Root Maggot*, side view, enlarged; the hair line beneath represents the natural size. a, dorsal view of caudal segment, showing size, number and arrangement of fleshy tubercles, much enlarged; b, outline of a cephalic spiracle, greatly enlarged.

A full grown maggot measures .32 of an inch (8 mm.) in length. On each side of the body just back of the head is a minute, light brown, fan-like projection, or spiracle (shown greatly enlarged at b in figure 2) which leads into the trachea or breathing organs of the maggot.* These trachea extend the length of the body in two main trunks which throw out many ramifying branches, and again open to the surface near the center of the flat oblique caudal end of the maggot in two raised, roughened, darker brown or blackish spiracles shown near the center of figure 2, a. Around the margin of this

flattened caudal end of the maggot there are 12 fleshy pointed tubercles; the two lower ones are larger, of a brownish color, and always bifid or two-

* Bouché describes these cephalic spiracles as having 7 to 9 divisions. This seems to be true of the young larvæ (those about one-half grown), but in full grown specimens we find the number to be usually 12. The number varies slightly and thus may not prove of much specific value.

toothed,* thus making 14 fleshy points in all (Fig. 2, *a*). The tubercle on the margin just above these bifid ones is equally as long but narrower. The other tubercles are comparatively small, and the four lateral ones, two on each side, are a little below the margin. On the venter, a little cephalad of the bifid tubercles and just caudad of the vent, are two more fleshy pointed tubercles projecting caudo-ventrad. The number, size, and arrangement of these tubercles about the caudal end of the maggot (Fig. 2, *a*) have been given in detail, for our observations lead us to believe that they, especially the four larger more ventral ones, offer specific characters by which the Cabbage Maggot may be easily recognized and separated from the other common Anthomyiian maggots.

In short, the full grown cabbage maggot is about .32 of an inch (8 mm.) in length, white, cylindrical, tapering cephalad and obliquely truncate caudad with 12 fleshy tubercles around the caudal margin, the lower two of which are two-toothed; and the cephalic spiracles have 12 divisions.

The puparium.—This is the name applied to the case within which the maggot passes through a wonderful transformation which results in the perfect insect. This puparium is really the skin of the maggot which has hardened and separated from the creature within, which is then called the pupa; thus the maggot uses its own skin as a home to protect it while it changes to a tender pupa and thence to the perfect insect.

Many gardeners have doubtless seen these puparia, but did not realize that they were an important stage in the life of this pest. They can easily be found in the soil about badly infested plants in June. As shown in figure 3, the puparium is elliptical ovate in form, and being simply the dried skin of the maggot, it naturally shows the same fleshy tubercles at the caudal end, usually less distinctly but sufficiently distinct for the specific determination of the insect. It varies from a light to a dark brown in color, depending on its age, whether a few hours or several days old. It is shorter than the maggot, measuring only about .2 of an inch (5 mm.) in length; there is considerable variation in size, some being fully one-third smaller than others.



FIG. 3.—The puparium, dorsal view, much enlarged.

* Dr. Fitch says this is not true of the smaller young larvae. I have not examined specimens less than one-half grown, but it holds true for all I have seen.

As the whole future destiny of the insect is enclosed in these puparia, gardeners should be able to recognize the pest in this stage so that they may destroy them at every opportunity, thus "nipping in the bud" a future destructive crop of maggots.

The adult insect.—After a certain period of incubation in the puparia just described, this pest appears as a creature totally different from the familiar maggot. It is the adult insect, which is known as the fly of the Cabbage Root Maggot by the few gardeners who are familiar with the pest in this stage. Both sexes of the fly are shown greatly enlarged (the hair line beneath each indicates their natural length) on plate I; the right legs and wing were removed before photographing so that the details on the other legs and wing might not be obscured. By the casual observer the adult insect might easily be mistaken for the common house fly. It resembles the house fly in general appearance, but, although it varies somewhat in size, it is considerably smaller. Like the house fly, it has only two wings, but in the cabbage fly these extend farther back beyond the end of the body and are shut farther over each other on the back of the fly. The body of the fly is about .2 of an inch (5 mm.) in length, and the sexes differ considerably; some of these differences are well shown in the figures on plate I, as will appear from the descriptions of each sex which follow.

The male fly is of a general dark ash-grey color with three rather broad blackish dorsal stripes on the thorax, and a wide, black, dorsal stripe extending along the abdomen becoming narrower toward its extremity and more or less dilated opposite the upper margin of each segment which is marked with a narrower transverse black stripe. Many bristly hairs project from different parts of the body, and the abdomen is sub-cylindrical, narrow, and but slightly tapering. The eyes, occupying a greater portion of the head, nearly touch each other above. The legs are black and strongly bristled; on the under side of each hind femur near its base is a tuft of these bristles which are characteristic of this Cabbage-fly. This tuft is quite noticeable on the femur of the male fly in figure 4, especially when comparison is made with the corresponding femur of the female shown in figure 5; by this character alone, the male insect can be recognized and separated from the other common Anthomyiid pests. There is also a characteristic row of short bristles, unequal in size, on the inner side of the hind tibia of the male insect that will help to distinguish the species.

The female fly, figure 5, plate I, is of a lighter ash-grey color, quite indistinctly striped on the thorax and abdomen, and not so strongly bristled as

PLATE I.



FIG. 4.—*The male fly, side view with right legs and wing removed, greatly enlarged ; natural length of the body represented by the white hair line below.*

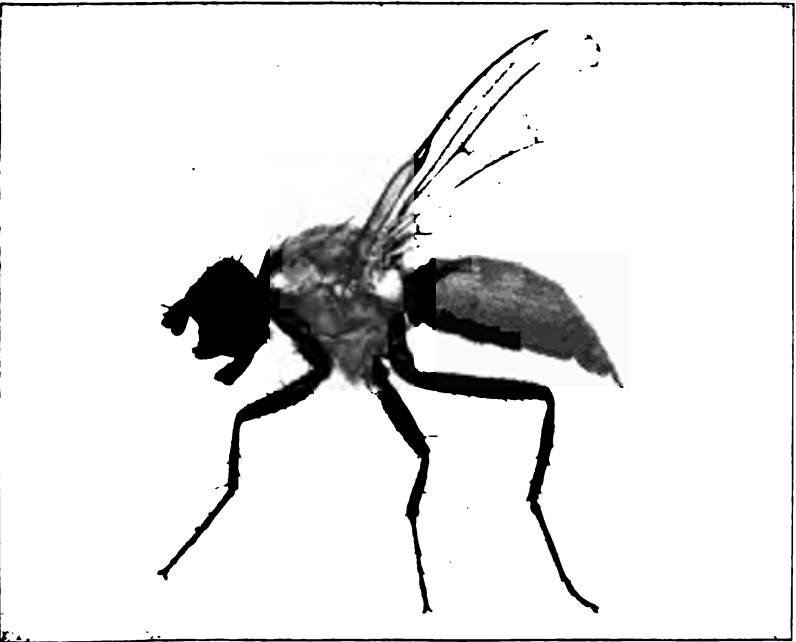


FIG. 5.—*Female fly ; similar view and magnification as the male fly in figure 4 above.*

the male. Her eyes are also quite widely separated above. The abdomen is of a more elongate ovate shape with a pointed apex. There seems to be no special characteristic by which the female fly can be recognized and separated from some of the other common Anthomyiids; it is necessary that it be found associated with its male to determine it with certainty.

Gardeners who are not now familiar with these flies can soon become so with the aid of the above descriptions and illustrations, supplemented with a knowledge of their habits and times of appearance which are discussed farther on under the life history of the pest.

ITS CLASSIFICATION.

This cabbage pest is a member of that peculiar order of insects—the true flies—known as the *Diptera*, none of whose members have more than two wings. The well-known House Fly, the Mosquitoes, the Hessian Fly, the Crane-flies, the Bot Flies, and many other familiar insects are typical members of this order. The pest under discussion belongs to the family *Anthomyiidae* whose members are commonly known as the Anthomyiids, which in the original Greek means “flower flies,” from their habit of frequenting various flowers. There are more than a hundred other members of this family in this country, and among them some well known pests like the Onion Maggot, and others. The Cabbage Root Maggot is probably the most common and best known member of the family.

Its scientific name.—Naturalists are not agreed as to the name by which this insect should be known. After a critical survey of all the evidence known to us, we are convinced that the pest should be called *Phorbia brassicae*.*

Other names have been applied to the insect as is shown in the synonymy of the pest on another page, but we believe the weight of evidence at present is decidedly in favor of *brassicae*, the name given by Bouché in 1833. This specific name of the pest comes from the generic name *Brassica*, of the plants on which the insect usually feeds. Until within a few years, the insect has usually been referred to the genus *Anthomyia*, sometimes to *Chortophila*; but the latest authority places it in the genus *Phorbia*, hence its complete name is *Phorbia brassicae*.

*For a detailed account of our reasons for adopting this name, see the discussion which follows the bibliography of this insect on the last pages of this bulletin.

Its popular name.—From the time the insect first became known by a scientific name, it has been popularly known as the Cabbage-fly or maggot, and equally as commonly known as the Radish-fly or maggot; some have more correctly called them Cabbage or Radish Root Maggots. It has also been called the Cauliflower and the Turnip-maggot when these were the crops under discussion. No one has doubted that the common Cabbage, Cauliflower, and Turnip-maggot were the same insect, and we now believe the Radish-maggot is also the same.*

Therefore, its scientific name, *brassicae*, at once suggests the cabbage, and the insect is more familiar to gardeners as the maggot infesting the several varieties of cabbage than as the radish-maggot; for these reasons we use the popular name of Cabbage-fly, or better and more familiar to gardeners, the Cabbage Root Maggot.

•

COMPARISON OF THE PEST WITH OTHER COMMON ROOT MAGGOTS OR ANTHOMYIANS.

Our study of this pest has been greatly complicated by the lack of definite comparative knowledge of it and some other common Anthomyiians which have been confounded with it. This lack of comparative knowledge has given us a somewhat complicated synonymy for the insect, and has led some observers to confound two or three different insects.

We have found that there are three common Anthomyiians more or less intimately associated with the Cabbage Root Maggot, two of which doubtless attack the same plants. To save future observers the labor it has cost us to understand these closely allied and easily confused root maggots, it seems advisable to include in this bulletin the following brief discussion of each of these allied forms.

*A detailed discussion of our reasons for believing the common Cabbage and Radish-maggots to be identical is given on a previous page under the food-plants of the pest, and also from the systematist's standpoint in the discussion of the synonymy near the end of the bulletin.

THE ONION MAGGOT.

Phorbia ceparum, Meigen.

This Anthomyiid has been recognized as a formidable pest by onion growers, both in Europe and America, since the beginning of the present century. It is probably as widely distributed, and as destructive wherever it occurs, as is the Cabbage Root Maggot.

The insect is *par excellence* the Onion Maggot, for it seems never to have been recorded on any other food-plant. Its presence in an onion bed is indicated by the leaves becoming soft and flaccid to the touch, often changing to a yellowish color, and finally wilting.

The maggot closely resembles the Cabbage Root Maggot (Fig. 2) in size, shape and color.

The caudal segment, however, is quite different in the arrangement and number of its fleshy tubercles; figure 6, *d* and *e*, represents the caudal segment of the Onion Maggot as seen from the side and from above. There seems to be no difference in the size, number, and arrangement of the dorsal and lateral marginal tubercles in our common root-feeding Anthomyiids; there seems to be always eight small ones. There is often a decided difference in the two ventral marginal tubercles, however, as a comparison of *e*, figure 6, and *a*, figure 2, will show. In the Cabbage Root Maggot these two are always bifid, while in the Onion Maggot they are single pointed. The latter also has, in addition to the two tubercles just caudad of the vent, two smaller ones on the venter just cephalad of the two large ventral marginal tubercles; the tips of these small tubercles appear between the larger ones when the caudal segment is viewed from above as shown at *e* in figure 6. The number of divisions of the cephalic spiracle is usually ten, but sometimes eleven or twelve.* Thus the Onion Maggot is easily distinguishable from the Cabbage Root Maggot.

The adult insect, the Onion Fly, closely resembles, but is slightly larger than the Cabbage Fly. Both sexes of the Onion Fly are of a light grey color, with the thorax of the male marked with four indistinct brownish



FIG. 6.—*a, b, c*, right hind leg of the male of the Onion Fly, the Cabbage Fly, and the Fringed Anthomyiid, respectively. *d*, side view of caudal segment of the Onion Maggot; *e*, dorsal view of the same. All are much enlarged.

*I have not been able to compare fresh specimens of the Onion Maggot; with such specimens, I presume other distinctive characters would appear.

stripes and a sub-continuous stripe of rather indistinct narrow triangular black spots down the dorsum of the abdomen. A glance at the hind femur of the male Onion Fly will readily distinguish it from the one infesting cabbage. At *a* in figure 6 is shown the right hind leg of the male Onion Fly greatly enlarged, and at *b*, the same leg of the Cabbage Fly; the tuft of hairs at the base of the femur in *b* is a striking contrast to the comparatively bare base of the femur of *a*, the Onion Fly. The female flies of these two species are not easily separable unless found associated with their males.

As the name of this onion pest indicates, it is closely allied to the Cabbage Root Maggot; they belong to the same genus, *Phorbia*. Its specific name *ceparum* comes from the specific name of its food-plant, the onion (*Allium cepa*).

The life-history of the Onion Maggot, so far as recorded, shows that it is very similar to that of the Cabbage Root Maggot. Thus our discussion of this phase of the latter insect will be of equal interest, in many respects, to onion growers. From the nature of the difference in the vegetables attacked, the Onion Maggot probably differs somewhat in its habits, but many of the statements we make regarding the life-history of the Cabbage Root Maggot will also apply to the Onion Maggot.

Some, and doubtless all, of the natural enemies which we record as attacking the Cabbage Root Maggot, also prey upon the Onion Maggot.

Our detailed discussion of the methods of preventing the ravages of the Cabbage Root Maggot, especially when it attacks radishes, will be found equally applicable to this most formidable pest of the onion grower.

Therefore, onion growers should understand that although this bulletin primarily treats of the Cabbage Root Maggot, much that it contains applies equally well to their worst pest, the Onion Maggot; especially is this true as regards the discussion of the life-history and methods of combating the former pest.

THE ROOT MAGGOT.

Anthomyia radicum, Linn.

Although this insect has been known for more than a century (it was described by Linnaeus in 1761), our knowledge of its

habits and life-history is very indefinite and meagre. The writer has never seen the insect in any stage, so cannot hope to add anything new to what has already been recorded. But this Root Maggot has often been confounded with the Cabbage Root Maggot, as our synonymy of the latter insect shows. And as this confusion of these species has cost us no little trouble, we desire to here record what we have been able to learn about it from very scattered sources, with the hope that it may help to clear the way for others; and especially that it may induce some observer, opportunely situated, to give us more definite knowledge regarding this Root Maggot.

It is an European species, and has been discussed by several German and English writers. However, there seems to be no record of any extensive damage to crops directly and definitely traceable to it. True, Curtis discussed it as a turnip pest in England in 1843, but we now know that his turnip maggot was not the Root Maggot, but undoubtedly the Cabbage Root Maggot.*

The only reason for believing that this Root Maggot occurs in this country is the fact that in 1878 one of the flies was found by Mr. Meade in a collection of flies sent him from the Cambridge Museum in Massachusetts. No other specimens are at present known to exist in this country, and no injury has as yet been traceable to the species here.

All accounts of the maggot of this insect are compilations of Bouché's description (in 1834) of a maggot which he said occurred by the thousands in human dung. He describes a maggot very different from the Cabbage Root Maggot; his Dung Maggot is said to be muricated with black all over, even the fleshy tubercles on the caudal segment, and other differences appear in his description. If Bouché's description of this Root Maggot is correct, and

* Mr. Meade writes me that Curtis' illustration of the adult of his turnip maggot (which he called *Anthomyia radicum* Linn.) is a good figure of the cabbage fly. This figure has appeared many times in European and American literature as that of *radicum*. Curtis' account of these Anthomyians in his "Farm Insects" has been the mine from which many writers on the subject have drawn their information, yet Dr. Fitch seems to have been the only one who has heretofore doubted Curtis' determinations of the species. One or two other inaccuracies which crept into Curtis' account are pointed out for the first time later on in this bulletin; they have been handed down through the literature and now appear in several of the best discussions of the Cabbage Root Maggot in our American literature.

no one has yet questioned his determination of the species, it ought to be easily distinguished from the other more common cabbage and onion maggots.

The adult insect closely resembles the cabbage fly, and is recorded as occurring frequently in Germany and as excessively common in England.

Mr. Meade says it may be recognized by its projecting face; by the scales of the base of the wings being unequal in size; by the thorax being black and marked in the male by two short, grey, narrow stripes; by the rather short, wide, somewhat pointed abdomen, with a longitudinal dorsal black mark, crossed by three transverse straight black stripes extending of an equal width to the margins; and by the third and fourth longitudinal veins of the wings being slightly convergent at their extremities. This inequality in the size of the alular scales, the shape of the abdomen, the markings on the body, and the convergence of the third and fourth longitudinal veins of the wings are characters, any one of which would distinguish the male fly, at least, from the cabbage fly; a reference to our descriptions and figures of the cabbage fly will enable one to more clearly understand some of these differences.

In fact, the flies of the Cabbage Root Maggot and the Root Maggot differ so much that they are now placed in different genera. The Root Maggot belongs to the genus *Anthomyia*. Its specific name, *radicum*, indicates that it lives on the roots of plants.

However, as we have mentioned above, Bouché recorded the maggots as breeding in human dung. Other authors say it feeds on the roots of the cabbage tripe and on radishes. It would seem as though there must be some mistake here, for Bouché states that it needs only 8 to 10 days for its growth from the egg to the pupa. The pupa stage he says lasts 2 or 3 weeks. Nothing is said about it feeding on roots. It seems hardly probable that a maggot working in a living root would develop so quickly. This point should be investigated. If Bouché has made a mistake, it should be known, and the true Root Maggot definitely described.

One can readily see from this brief discussion of the Root Maggot, how incomplete and indefinite our knowledge is regarding its habits and early stages. It is to be hoped that some observer may be able to fill this gap in our knowledge.

THE FRINGED ANTHOMYIIN.

Phorbia fusciceps Zett.*

Our attention was first called to this insect by its appearing in June in some of our cages in which seed cabbages were growing ; later, in August, flies of the Cabbage Root Maggot appeared in the same cages. This indicated that both species fed on the cabbage, and led us to carefully examine all our material to determine if the former was also associated with the Cabbage Root Maggot in its work of destruction on early cabbage. Thus we were led to study the insect somewhat closely so as to be able to distinguish it from the other common Anthomyiins in case it should appear in connection with them. A study of the literature of the species showed that it was more intimately connected with the cabbage and onion Anthomyiins and was more common in this country than we had suspected. For these reasons it seems advisable to discuss the insect briefly in this bulletin so that future observers need not confound it with the other Anthomyiins with similar habits.

The insect is probably of European origin as it received its name in Germany in 1845. Eleven years later, Dr. Fitch found it in New York State and described it as a new species. It was again described as new in France in 1866. It has also been found in England. In 1869, Dr. Riley met with it in a new role and, supposing it to be a new species, gave it another name. Eight years later, while investigating the ravages of the Rocky Mountain Locust in the west, Dr. Riley again found the same insect but under such different conditions that he did not recognize it and again characterized it as new to science. In 1885, it was found in Canada ; and this year in Ohio. The insect is thus widely distributed in Europe and in this country.

*The synonymy of this species as recently worked out from an examination of types by Rondani, Meade, Stein, and Coquillett is as follows :

Aricia fusciceps Zetterstedt. 1845.

Hylemyia deceptiva Fitch. (The Deceiving Wheat Fly.) 1856.

Chortophila cilicrura Rondani. 1866.

Anthomyia zeae Riley. (The Seed-corn Maggot.) 1869.

Anthomyia radicum var. *calopteni* Riley. (The Locust-egg Anthomyiian.) 1877.

From the following brief record of the curious habits of this Anthomyiid, one may easily understand why an observer, finding the insect living in a certain manner in one locality, would not suspect that it could be the same one that he found in another locality feeding upon an object so different as to belong to a different kingdom in nature. Dr. Fitch named the insect "The Deceiving Wheat Fly," as he found the fly very numerous hovering over and alighting upon the heads of wheat at the time they are in flower; it was erroneously regarded by some as the fly which produced the yellow maggot of the Wheat Midge (*Diplosis tritici*). Nothing further has been recorded of this wheat fly, and it had always been considered a distinct species until Mr. Coquillett recently (Insect Life, vi, 372) discovered by an examination of one of Dr. Fitch's types that it was identical with the species under discussion. The insect is next mentioned in our economic literature as a maggot working in sprouting seed corn in New Jersey, and was named the "Seed-corn Maggot (*Anthomyia zea*)" by Dr. Riley. This insect seems not to have again been reported injuring corn in this manner.* A few years later, the insect appeared in a decidedly beneficial role. In the autumn of 1876 it is estimated that its maggots destroyed about ten per cent. of the locust eggs in Missouri, Kansas, and Nebraska, and also sucked thousands of these eggs in the States of Minnesota, Iowa, Colorado, and Texas. Dr. Riley named it the "Anthomyia Egg Parasite," and considered it a variety of the Root Maggot (*A. radicum*). In the same account of this locust-egg feeder, Dr. Riley says he has bred the same flies from cabbage and radish. It is probably not very common on these vegetables; we have not met with it among the hundreds of specimens of the maggots or flies from early cabbages, which we examined. Its occurrence in connection with the Cabbage Root Maggot on seed cabbage has been noted above. In 1882, the insect was found in England feeding on onions and associated with the Onion Maggot. In 1885, it was found working on the stems of young bean plants in Canada; and this year it worked serious injury in bean fields in Ohio. Dr. Linter has recently bred the insect from seed potatoes. This summer we bred the fly from a maggot found on the roots of Hedge Mustard (*Sisymbrium officinale*).

This is an astonishing array of food for such an insect. It includes sprouting seed corn, eggs of locusts, cabbages, radishes, onions, beans, and hedge mustard. It is thus not a strict vegetarian like its near relatives; and, when sucking locust eggs, it is

*I am indebted to Mr. L. O. Howard, United States Entomologist, for the privilege of examining Mr. Coquillett's manuscript notes on the synonymy of *fusciceps* Zett., included in which I found this "Seed-corn Maggot;" doubtless the reference was made from an examination of Dr. Riley's types.

In a collection of Anthomyiids recently received from Mr. Fletcher I found a female fly which bore the label: "Bred from Indian Corn, destroying the sprouting seed," with no date. My notes on this specimen, made at the time, read: "Probably a female of *Phorbia ciliicrura*,"—*P. fusciceps*.

a very beneficial insect. Mr. Meade writes Dr. Lintner recently : "It is very curious that it should feed both upon animal and vegetable food. Some Muscids (in larva state) eat decaying (rotten) animal and vegetable matter, but I was not aware that they would feed upon them in the fresh state."

None of the popular names which this insect has received adequately express what such a name should. It would be difficult to get a name that would suggest such a variety and diversity of food habits. We therefore propose a popular name—the Fringed Anthomyiian—which was suggested by a peculiarity which distinguishes the adult male insect from other American Anthomyiians.

The fly very closely resembles the Onion Fly, but is considerably smaller.

The character by which this fly can be distinguished and separated from all other Anthomyiians is to be found in a row of short, rigid, bristly hairs of almost equal length on the inside of the hind tibiae of the males, as shown at *c* in figure 6. Thus the popular name—the Fringed Anthomyiian—at once suggests this characteristic fringe of hairs of the male insect. As is shown at *a*, *b*, and *c* in figure 6, this "fringe" on the tibia of this insect renders it easily distinguishable from the male flies of the Cabbage Root Maggot and the Onion Maggot; the fly of the Root Maggot also has no similar armature on its hind legs. The females of this species can scarcely be separated from allied Anthomyiians unless found in connection with their males; usually the smaller size of the female of the Fringed Anthomyiian will distinguish it from the Cabbage and Onion Flies.

The maggots of this Fringed Anthomyiian very closely resemble the Onion Maggots. The only differences we find (from a study of only two or three specimens of each species) are in the size of the full grown maggots, and in the number of divisions of the cephalic spiracles.

The maggots of the Fringed Anthomyiian are considerably smaller, and there is apparently only 6 or 7 divisions in their cephalic spiracles, one specimen having 6 in one spiracle and 7 in the other; there are usually 11 or 12 divisions in the Onion Maggot. The figure of the caudal end of the Onion Maggot, at *d* and *e* in figure 6, will represent equally well the same portion of the maggot of this species, so far as our few specimens indicate.

Thus these two species are closely allied in both their adult and larval stages, and both feed on the onion, "passing through their transformations at the same time," says Mr. Meade. How-

ever, there need now be no confusion of the adult male insects, and doubtless, when larger numbers of fresh specimens of the maggots are examined, characters will be found to readily distinguish them.

The life-history of this Fringed Anthomyiid is doubtless very similar to that of the Cabbage and the Onion Flies; in its beneficial role of sucking locust eggs, it may differ somewhat. Thus, with a similar life-history, the methods recommended for combating the Cabbage Root Maggot when it attacks radishes, will prove equally effective against this Fringed Anthomyiid should it ever occur in destructive numbers, which it seems not to have yet done.

RELATION OF THE PEST TO THE "CLUB-ROOT" OF CABBAGE.

The peculiar affection of cabbage roots shown in figure 7 is familiar to gardeners as the "Club-root," "Club-foot," "Clump-foot," or "Clubbing" of cabbage. It is an old enemy, having been known in Europe for more than a century, and American cabbage growers have suffered from it for at least half a century. The total loss from this disease aggregates thousands of dollars annually; it is particularly destructive in the eastern truck gardens in the vicinities of the large cities.

For many years after the disease was known to exist, it was believed to be caused by insects. And this is not to be wondered at, for often various insects are found in such intimate connection with it that its cause would naturally be attributed to them. The insect that is most often found in connection with the Club-root in this country is the Cabbage Root Maggot. In England the Turnip and Cabbage Root-gall Weevil (*Ceutorhynchus sulcicollis*) also occurs with the Club-root.

The maggots of this last insect cause round gall-like swellings on the roots within which they feed; and by the casual observer these weevil galls might easily be confounded with the Club root. But these galls are commonly regular in formation, like rounded smooth knobs, and on cutting them open one does not find a mass of disorganized tissue as in Club-root, but there is a central chamber which has been gnawed out by the maggot then to be seen

lying within or which may have recently left through a distinct exit hole to go into the soil to transform. Thus, these galls made by weevils ought to be easily distinguished, wherever found, from the gall-like swellings of the Club root.*

Previous to 1876, in the books and newspaper writings of American gardeners, the Club-root of cabbages was usually associated with, and recorded as being caused by, the Cabbage Root Maggot. Peter Henderson was one of the foremost believers in this idea; and in his 1887 edition of "Gardening for Profit," although he seems to have abandoned his idea of its being caused by this maggot, yet he attributes Club-root to an insect, but does not say what one. The disease caused much speculation among scientific observers for many years before its true cause was discovered. The lives and habits of the insects sometimes found accompanying the disease were studied carefully, but all efforts failed to convict any of them of being the author of the injury. Finally, after three years (1873-1876) of exhaustive and painstaking labor, an European botanist, M. Woronin, explained the nature and cause of the disease. He showed it to be caused by a low form of fungous growth, one of the Slime Moulds (*Plasmodiophora brassicæ*). Other investigators have since studied the disease and all agree that it is primarily caused by this Slime Mould.

Thus, while there is no doubt that the Cabbage Root Maggot is often found attacking Club-rooted cabbage, it is also a fact that the maggots destroy thousands of plants where there is no trace of Club-root; and it is also true that the Slime Mould of Club-root is the sole cause of the death of thousands of plants in fields

**Ceutorhynchus rapæ* Gyll. has been recorded injuring cabbages in Missouri by Miss Murtfeldt (Rept. of U. S. Entomologist for 1883, p. 136; also Bull. 30 of the Ent. Div., p. 50). We have found a closely allied species, "perhaps new" says Dr. Horn, doing great damage in fields of seed cabbage on Long Island. The grubs burrow in the pith of the seed stalk and its branches. Often hundreds occur in a single stalk, and sometimes whole fields of seed cabbage are ruined by the stalks wilting and breaking over just before the seed begins to mature; thus nearly the whole crop of seed has sometimes been lost by the depredations of this Seek-stalk Weevil (*Ceutorhynchus* sp.). We have found what is probably the same species of insect exceedingly numerous here at Ithaca boring in the stems of the Shepherd's Purse, the Common Winter Cress, and the Hedge Mustard; in fact, nearly every plant of the above weeds found near the insectary in July had their pith riddled by the maggots of this borer. The cabbage seed growers on Long Island thought that this stalk borer was the Cabbage Root Maggot; the maggots having simply continued on up the stem into the pith of the seed stalk. We found no Cabbage Root Maggots in the seed stalk, but they occurred in company with the Fringed Anthomyiid and other maggots on the buried stem of the plant.

This Cabbage Seed-stalk Weevil is a very serious pest in this great seed region on Long Island and should be carefully investigated. We found it difficult to breed here in the insectary, and thus far have learned but little regarding its life-history and habits. At present we can suggest no more practical method of combating the pest than to keep the fields free from Cruciferous weeds, and remove and burn all infected seed stalks as soon as noticed; after a little experience, these stalks can probably be easily distinguished from the others.

where there are no maggots. Thus the Club-root of cabbage is a disease of itself entirely distinct from the work of the Cabbage Root Maggot or any other insect.

However, it still seems to be the general belief among American entomologists that either "there can be but little doubt but that the work of these larvæ (Cabbage Root Maggots) is one of the several causes of 'Club-root' of



FIG 7.—"Club-rooted" Cabbages; about $\frac{1}{2}$ natural size.

cabbage," as Dr. Riley said in 1884; or that "they sometimes cause the roots to thicken up and become malformed, producing an effect similar to that of the fungus causing the disease known as 'Club root,'" says Weed in his "Insects and Insecticides." Our observations of the work and habits of the maggots in the field and in the insectary lead us to believe with Miss Ormerod (Rept. for 1892, p. 143) that the maggots "bore into the roots and cause mischief, sometimes to a very serious extent, by the decay thus originated, as well as by their destructive gnawings; but they do *not* cause gall growths, nor do they cause the diseased, enlarged growth which we see in the case of 'Finger-and-Toe,' or 'Club.' * * * (p. 159). The Club is *entirely and absolutely* distinct in its nature from any insect attack." True, as the same author says, the cabbage stalk or turnip root may swell slightly and often become putrid from the attacks of the maggots, and under these conditions

might be mistaken by the casual observer for the beginning stage of the Club-root attack. But the gall-like stage of the fungus is soon reached, when it should be easily distinguished from the possibly slight swellings with their accompanying maggots.

In short, the only relation of the Cabbage Root Maggot to the Club-root is that it is often found associated with it, and perhaps feeding upon or even within the gall-like excrescences produced by the Slime Mould. However, the Club-root is a disease entirely distinct from the maggot attack and the maggot is not one of the causes of the disease, for although both sometimes thus occur in intimate connection, they also frequently occur entirely independent of each other, in this case producing effects on the roots that could scarcely be confounded.

THE LIFE-HISTORY OF THE PEST.

But little has been added to our knowledge of the life-history of the Cabbage Root Maggot since it first became known in the early part of the century. Curtis, Fitch and Fletcher have added a few details regarding the method of oviposition, and habits of the maggots and flies. And yet our observations indicate that there is still much to be learned of the habits and life-history of the pest, especially during the latter part of the summer.

Our observations on its life-history have been carried on mostly at the insectary. Unfortunately, and much to our surprise, we have had but little success in breeding the insect in our cages. And as our base of operations was so far away (the extreme eastern end of Long Island), but few field observations were practicable. However, our investigations have brought out some new and surprising facts which should be supplemented by a careful study of the pest in the field. We believe there are several phases of the insect's life that are not yet understood, which would repay careful investigation.

Its first appearance and habits in the spring.—No one seems to have recorded any more definite time than early in the spring for the first appearance of this pest for the season. The form in which the pest always appears at this time is that of the adult insect. From whence they come is discussed later under the subject of hibernation. Of course, the date of the appearance of the flies in

the spring will depend somewhat upon climatic conditions, latitude, and the locality. This year they appeared on Long Island in the latter part of April and during the first week in May. The cabbage plants were set about April 18; somewhat later than usual, gardeners said. Sometimes the pest has appeared early enough to attack plants before they are removed from the seed beds.

In 1826, Meigen said the flies were common in the spring on the blossoms—the familiar “pussies”—of willows. Doubtless further observations on this point will show that they frequent any other blossoms that are accessible so early in the spring.

Mr. Fletcher seems to have more closely observed the habits of the flies about cabbage plants than anyone. He says, “The females will spend a good deal of time running over the earth and trying to find some crevice” in which to oviposit.

If gardeners who are troubled with this pest will closely watch their plants for a few days after setting out, they cannot fail to observe these little flies, resembling house-flies but smaller, on and around the plants. If the flies seem at all numerous, the grower may expect trouble from their progeny and should act accordingly. Whenever the flies are seen, a day or two later the next stage of the insect, the egg, may be found.

Oviposition.—Many observers have seen the eggs and described their method of oviposition, and yet, strangely enough, there is hardly a clue in the literature as to what these eggs are like. In laying their eggs, Mr. Fletcher says the females spend some time in “trying to find some crevice by which they can creep beneath the surface of the soil and lay their eggs close to the stem, or they will creep close up to it and push the eggs down below the surface by means of their extensile ovipositor.” (In figure 5, plate I, this ovipositor is shown partly extended from the end of the abdomen of the female fly.) Some observers say the eggs are laid on the surface of the soil; this may happen where the soil gets packed closely about the stem, leaving no crevice.

A correspondent wrote the “Rural New Yorker” in 1887, that he watched the flies carefully in the spring and found that all the eggs were laid about his cauliflower plants within 4 or 5 days’ time. They are laid one to twenty on a plant, close to the

stalk on the soil and are readily seen with keen eyes. In 1887, Prof. Cook recorded finding hundreds of eggs about a single plant. This is no exaggeration, for we have found at least 300 maggots at work on a single cabbage plant.

Several flies must lay their eggs on one plant to produce such a crop of maggots; and when only 10 or 20 maggots occur, a single fly must oviposit on several plants. This statement is based on the following observations. April 9, a female Cabbage Fly emerged in a cage in which young cabbage plants were growing here at the insectary. She laid no eggs, and died on April 13. An examination was made of the contents of the abdomen, and it was found to be packed full of eggs. Fifty-five of these, apparently fully developed, eggs were removed one by one, before the abdomen was emptied; no partly developed eggs were seen. Thus 55 is probably about the normal number of eggs laid by one fly.

Although the eggs are very small, measuring only .04 of an inch (1.1 mm.) in length, their whitish color renders them quite easily seen by keen eyes, lying as they do close to the stem of the plant with the dark soil as a background. One of these eggs is shown greatly enlarged at *a* in figure 8. The minute hair line near the centre of *b* represents the natural length of an egg. *b* in the figure represents, in outline, the shape of the egg when viewed from the side. When examined under a microscope the egg shell presents the curious irregularly ridged appearance as shown at *a* in the figure. The figure also shows the large deep groove which runs along its whole length becoming deeper as it approaches the blunter or head end of the egg.

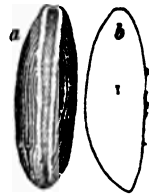


FIG. 8. - *a*, the egg, greatly enlarged; the hair line near the center of *b* represents its natural length. *b*, outline of side view of an egg.

Apparently all writers have followed Taschenberg (1865), in stating that the eggs hatch in about ten days. Mr. P. H. Scudder, of Glen Head, Long Island, who has observed this pest closely, told the writer that the eggs hatched in from four to ten days, depending upon the conditions of the weather; a cold spell retarding their hatching. Eggs began to hatch in Mr. Reeve's field at Mattituck, L. I., this year about May 8.

May 11, he sent us many of the eggs; they were sent in a box nearly full of soil, and reached us in seemingly good condition. They were at once isolated on pieces of dampened blotting paper; but not an egg hatched. This would indicate that the eggs are easily injured if much disturbed; and it may explain the success of one of the remedial measures to be discussed later.

We have had several of the flies emerge in cages of young cabbage plants, from hibernating puparia brought from Long Island; and also have had hundreds of the flies of the second brood emerge in large frame cages (figure 10) containing radish, turnip, cabbage, and hedge mustard plants. Yet the female could not be induced to lay a single egg; while flies came in from out of doors and freely oviposited on similar plants growing exposed in a bed but a few feet from the cages. Thus all our efforts to breed this insect from the egg in confinement, have thus far been unsuccessful.

Habits of the first brood of maggots.—In emerging, the maggot pushes through the blunter end of the egg which splits down along the sides of the deep groove. The young maggots at once attack the surface of the root. By means of its strong, curved, hook-like mouth parts shown much enlarged in figure 9, it soon rasps out a burrow along the surface. The tender rootlets seem to be the first objective point of the young larvæ. These destroyed, the maggots turn their attention to the main root into which they burrow, often girdling it as shown in figure 1. The figure on the front of the bulletin shows the maggots at this work, and their effect on a cabbage root.



FIG. 9. — Mouth parts of the maggot, greatly enlarged. (Adapted from J. B. Smith.)

Usually the maggots are found in slimy burrows in the bark just beneath the surface; and sometimes one is found just entering the bark, "with the end of its body projecting stiffly out, like a peg driven in half its length," as Dr. Fitch describes it. The interior portion of a rather large cabbage root is so woody that the maggots do not often work in it, but they sometimes penetrate into the interior of the softer stem farther up. When but a few maggots occur on a root, they are usually to be found in their burrows; but often so many maggots attack one plant that as they increase in size there is not room for all in the bark. In this case, as Mr. Fletcher says, "most of them lie outside in the soil, which is kept wet by the juices of the injured plant." Where we have seen this state of affairs, the maggots were nearly full grown and the plant had toppled over. Thus, all the maggots doubtless had access to the plant for food during much of their life, but probably they were being nourished by the juices exuding from the injured plant when found. When this stage in the ravages of the maggots is reached, on a cabbage plant especi-

ally, the slimy mass of soil and the then rotting roots combine to give out one of the most sickening odors imaginable.

The maggots work in a similar manner on radishes and turnips, except that often their slimy burrows extend irregularly about in the interior of the succulent root. Gardeners attribute much of the toughness and stringiness of turnips and radishes to the work of these maggots.

In 1878 Dr. Riley found the maggots not "only working in the normal way on the roots, but also burrowing in the stout mid-ribs of the leaves." Mr. Fletcher noticed a few of the maggots working in a similar manner at Ottawa in 1890.

Most writers, following Bouché, state that the maggot stage lasts from three to four weeks. Mr. Whitehead of England says from 24 to 28 days. We have no definite record on this point, but our observations indicate that under favorable conditions many of the maggots of this first brood attain maturity in less than three weeks.

The cabbage plants in our experiment plot on Long Island were not set until April 18 this year, but we bred a few flies as early as May 29 from maggots taken from some of these plants; thus the egg, larval, and pupal stages must have been passed in less than 41 days. Most of the maggots of this first brood matured during the last week of May and the first few days of June this year on Long Island. But maggots of various sizes occurred May 20. This was doubtless due to some of the flies appearing and ovipositing later in the spring than others.

Pupation.—When the maggots get full grown, they usually work their way for an inch or two into the soil away from the roots, and there enter the pupal stage. Sometimes this change takes place in the galleries which the maggots have made in the roots. The change from the maggot to the pupal stage is quite gradual. The casual observer would notice but little difference between a full grown maggot and a puparium which was only an hour or two old; they are of the same color, but the latter is a little shorter, slightly more elliptical in shape, and shows a certain stiffness not seen in the maggot. These puparia can be easily found if the soil around the base of a badly infested plant be closely examined, for a depth of two or three inches, at almost any time from June 1 until the next April.

In an hour or two after the puparium is formed, the skin begins to turn brown, and usually reaches a light cinnamon color in eight or nine hours. Some do not get much darker, but others pass to a dark seal brown color. They vary considerably in size, some being a third smaller than others. It was at first thought that this might be a sexual difference, but both sexes of the flies emerged from some of the smallest ones isolated for the purpose.

The duration of the pupa stage is stated by most authors to vary from two to three weeks in the summer. Mr. Whitehead says sixteen days. Dr. Riley records the appearance of the flies after only eight days of pupation. Most of the puparia under our observation gave out the flies in about twenty days, in June; with some it lasted only fifteen days, with quite a number nearly two months, with others three months, and from a few the flies had not emerged by September 5, or three and a half months after the puparia were formed. These are very surprising facts when one understands that all of these puparia came from the first brood of maggots. There is no hint in the literature of any such retardation in development. Yet our observations are conclusive.

For instance, nine puparia were put in a tumbler May 23, and flies emerged and were removed on the following dates, one on June 7, one on June 8, three on June 10, one on June 14, one on August 18, and one on August 23; one puparium was opened August 18 and it contained a fly pupa. These dates also correspond very closely with our notes on the appearance of the flies in our larger cages (figure 10), where hundreds of them emerged during the summer.

This state of affairs complicates matters, especially as regards the later broods of the pest. It is even possible that some of the first brood of puparia hibernate. We comment further on this phase of the subject when we discuss the number of broods of the insect.

Habits of the flies in summer.—When the pupa is fully mature, it crowds against one end of its brown home, which soon splits open and allows the fly to emerge. As Dr. Fitch says, it "crawls up out of the ground, with its wings crumpled up, and climbing up the side of a clod or any perpendicular surface which it finds, these members expand and assume their proper form before they become dried and firm." The flies are frequently to be seen resting quietly for several minutes at a time on different parts of the food-plants of the maggots. As the Anthomyiids frequent flowers, doubtless the cabbage fly will be found on the various blossoms growing in or near gardens during the summer.

How long the flies live in the summer is not known ; they lived ten days in our cages in the insectary. Doubtless they live but a few days after providing for the perpetuation of the species. The flies do no damage, for if they feed at all, it is only to eat a few grains of pollen or to sip a little nectar from some flower.

The number of broods, and habits of the later broods.—It appears to be the accepted belief among entomologists that there are three or four generations or broods of this pest annually. In 1884, Dr. Riley stated that "the number of broods in the course of a season has not been accurately followed in any given latitude, but there are at least three." Many authors have simply followed Bouché who said in 1833, that there were several generations of the pest during the summer. In 1874, Prof. Cook concluded that there were at least two broods.

A search through the earlier literature of the insect has revealed the probable source of this idea that the pest passes through three or four generations annually. In 1865, Taschenberg said : "Because they (the flies) need for their complete development, which begins with the early spring, on an average eight weeks including ten days for the egg stage, therefore must three complete generations in the course of a year be accepted as normal." Thus, the number of generations has been merely a matter of calculation, doubtless based on observations made only on the first brood in the spring.

There is no doubt that a brood of flies appears early in the spring, in New York State in the latter part of April and the first week in May. These flies, and their progeny of maggots which work on the plants in May, constitute the first brood or generation of the pest. This brood appears, in greater or less numbers, in all localities where the insect occurs. And in most localities, in most seasons, both in Europe and America, it is the most destructive brood, working in early cabbages, radishes, cauliflowers, and turnips ; sometimes attacking these plants before they are removed from the seed bed. We also found this brood the most numerous on the weeds upon which it feeds.

However, we find such statements as this from Dr. Fitch : "It is only my earliest sown radishes, each year, from which I obtain any that are fit for use, and for several years past, this first sowing has also been a total failure." Mr. Fyles also says that the radish fly "appears in the end of June and the beginning of July. I have found that radishes sown at Quebec in the beginning of May" are a success. Thus, in some localities, especially in Canada, and in some years the first brood of the pest is not noticeably

destructive ; but we believe it appears every year, in greater or less numbers, in all localities. Even in Canada, early cabbages are sometimes injured in the seed bed, says Mr. Fletcher.

The first brood is well defined ; the flies appear in April and their maggots work destruction in May on the roots of the cabbage tribe, on radishes, and on turnips. The time when the first brood of maggots mature will of course vary with the season. This year, on Long Island, they matured about June 1, changed to pupæ, and a majority of the flies had emerged by June 15. This date agrees closely with the recorded rearings of the flies from maggots of this first brood. Thus the second brood begins,

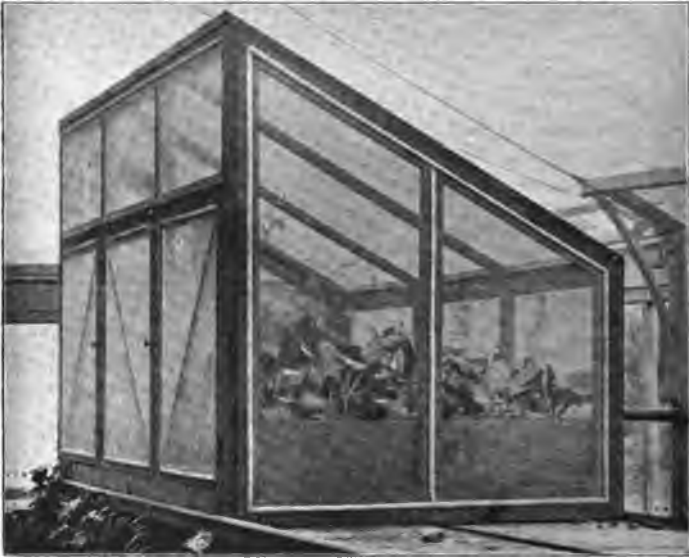


FIG. 10.—Cage devised for breeding the Cabbage Root Maggot.

in New York State, with the appearance of these flies about June 15. It should be borne in mind, however, as recorded above, that all of the puparia of the first brood do not give out their flies in June ; some do not appear for months after. Our observations indicate that at least 75 per cent. of the flies appear in June.

Although hundreds of these flies emerged in our large cages prepared especially for their comfort, none laid eggs all dying in a few days. One of these cages is shown in figure 10. It consists of a framework covered with

cheap tarlatan, and is screwed together for convenience in storing away. It is 7 feet long, 3 feet wide, $3\frac{1}{2}$ feet high at the front and 2 feet at the back; the top being made slanting to correspond with the glass roof of the insectary. For convenience in examining all parts of the cage, three large doors were made in the front as shown in the figure. The whole frame sets over a bed of earth made in a wooden frame. In this bed the different food-plants of the pest were grown. Although this cage proved a failure as far as breeding the Cabbage Fly is concerned, it will prove a valuable addition to our outfit for studying other, less particular, insects.

In one of these cages we kept growing various sizes of cabbages and hedge mustard from May 20 to August 3; and in the other cage several varieties of turnips and radishes were grown during the same period. The plants grew thriftily, and hundreds of the flies emerged from maggots and puparia placed in the cages. But for some unaccountable reason they would not oviposit. It would seem as though in these large airy cages the flies would be sufficiently at home to provide for the perpetuation of their species. And it seemed still more strange, when we found flies coming into the insectary (which is only a similar cage on a larger scale) from out of doors in June, and breeding on radishes and turnips in a similar bed only a few feet away.

Thus our efforts to rear this second brood of the pest in confinement has this year been a failure. And yet there is no doubt that the flies of this brood soon oviposit and a second destructive brood of maggots appear in July. For in the latter part of June, we found half grown maggots at work on some of the radishes and turnips in a bed in the insectary. These were doubtless produced by flies which appeared in the early part of June, or about the time the second brood of flies appeared in the fields. Furthermore, the recorded facts indicate that in certain years in some localities, this second brood is the destructive one. The testimony of Dr. Fitch and Mr. Pyles quoted above shows this. Mr. Fletcher says in 1890: "The greatest amount of injury is caused by a brood of flies which appears in the middle of June and up to about the first week of July." Thus in Canada, the second brood is usually more destructive than the first.

The natural conclusion from the above facts is that there is a second brood of the pest, which is often equally as destructive as the first; the flies of this second brood appear about June 15, and the maggots work in July. And the second brood evidently works in the same manner on the same food-plants as does the first brood; late cabbage also often suffers in the seed bed. The exceptional habit of mining the leaves of beets, recorded by Dr. Lintner, seems to have been the work of this second brood of maggots.

The definite recorded knowledge of this second brood seems to end with the maggots in July. When do the flies which are to produce the third brood appear?

Upon pulling up a turnip in a bed in the insectary on July 5, we found several nearly full grown maggots at work on it, and in the soil near by were a few puparia. Flies emerged from these puparia, July 16 and 20; the maggots produced flies on July 29, August 2 and 21. Thus the indications are that some of the puparia of the second brood give out their flies in about 20 days, while others remain as puparia for 40 days or more. As has been mentioned, the flies from the first brood of puparia also appeared at similar irregular intervals. Possibly a majority of the flies of the third brood (that is, those flies produced from the second brood of maggots) appear in the latter part of July. And curiously enough, some, possibly 20 per cent. of the puparia of the first brood gave out the second brood of flies in our cages about July 20; there had been no maggots in the cages and no flies had appeared since the middle of June.

Thus a portion of the third brood of flies emerge in July and are seemingly reinforced by a few belated members of the second brood. From this point our knowledge of this pest, both from the records and from our observations, is very meagre and fragmentary. The flies which emerge in July would be just in time to catch the late crops of their food-plants, and often the plants are then young and tender. But it is the universal testimony of gardeners that late crops of cabbages, radishes, or turnips suffer but very little, if any, from the maggots. Especially is this true of cabbages; some gardeners tell us the maggots seem to prefer to work on late radishes and turnips, and that these crops are the breeding places of the later broods.

In August, when the third brood of maggots would naturally appear, the early crops of cabbages, cauliflowers, radishes and turnips have been harvested. And as the late crops of these vegetables seem to be rarely, if ever, seriously damaged, the question naturally arises, if there are later broods, where do they develop?

There is no doubt that the maggots do work on the roots of their ordinary food-plants later in the season. Many writers record the occurrence of the insect after August, sometimes even in November. In 1891, the maggots wrought great destruction in a field of turnips at Ithaca in the early part of the season; and we found a few maggots still at work on October 3. But there are apparently no records of the maggots occurring in sufficient numbers to do serious damage after August 1. Thus no well-marked destructive broods of the insect seem to appear after the second one, on cultivated crops at least. Those found at work in August and later would seem to be scattered remnants or irregular broods produced by belated flies from the first brood of maggots, augmented by some flies which emerge from the second brood of puparia in July. Curtis' observations seem to support the view that

all of the flies from the second brood of puparia do not emerge the same season. Maggots working in turnips were sent him July 21. These were put, with a turnip root, in a flower-pot; but the flies did not emerge until the following April.

The above discussion indicates that the life history of this pest becomes quite complicated in July and August. We are able to definitely trace but two distinct broods of the pest, the second brood changing to puparia in July.

Hibernation.—Curtis says: "Many of the flies no doubt live through the winter, secreted in holes and crevices, and some of the pupæ do not hatch until the spring;" this is but a free translation of what Bouché wrote in 1834. All later authors agree with Bouché. In 1884, Dr. Riley said that "the insect hibernates both in the larva state in the roots and in the puparium state underground." Thus it has come to be the accepted belief that the pest passes the winter in all three of its later stages—the maggot, the puparium and the fly.

The experience of Mr. Fyles who, on November 21, examined radish roots on which the maggots were operating in October, and found no maggots, would indicate that the pest does not pass the winter as a maggot; and we are inclined to think that this method of hibernation is exceptional. For, early in April, while searching for the pest on Long Island, we examined many of these "stumps" left in the fall, but saw no indications of hibernating maggots. This point could be easily settled by some field observations in the winter or early spring.

Most observers agree that the usual method of hibernation is in the puparium. This is the form in which we found the insect early in April on Long Island. They were found in the soil around the base of "stumps" of early cabbage. However, but comparatively few were found in this situation, and we had no opportunity to examine the soil where late crops had grown. So few puparia were found that it seemed improbable that the pest would be numerous this season. But, notwithstanding the fact that the cabbage field was removed about 150 feet from last year's field, the maggots were more numerous than ever this season. This would indicate that either the pest bred freely in other late crops thus producing many puparia elsewhere, or that possibly many flies hibernated.

The indications, as shown in our discussion of the number of broods of the pest, are that possibly some of the first brood and many of the second brood of puparia hibernate, not giving out their flies until the next April.

Apparently the only evidence we have of the hibernation of the flies, is the statement of Bouché quoted above. We found but

few puparia early in April, and yet the flies appeared in large numbers three weeks later. These facts would indicate that many of the flies hibernated. It is not at all improbable that the flies do pass the winter secreted in crevices or under rubbish, etc. However, there is need of further evidence on this point.

NATURAL ENEMIES OF THE PEST.

☞ This pest, like many other insect pests, has several enemies among the animals, including those of its own kind—the insects. These natural enemies help to hold this pest in check, but the balance of nature has not yet reached that point where the scale tips in favor of the enemies. However, they are worthy of consideration, for the time may come when they will effectually check it.

Of the larger animals, two are recorded as feeding on the maggots. In the *Country Gentleman* for 1864, a correspondent is advised to turn his chickens into his cabbage patch to destroy the maggots. At one end of our experiment plot on Long Island, chickens injured some of the plants soon after they were set out. Later, when the maggots had appeared in full force, the chickens found them, and thousands of them were eaten, but usually the plants were also either pulled up or badly damaged. Thus, on the whole, it is hardly advisable to try to fight this pest with chickens, unless the plants are already beyond recovery.

In England, as Miss Ormerod reported in 1884, the Rooks sometimes tear up infested plants and hardly a maggot escapes them.

Several insects have been recorded as enemies of the Cabbage Root Maggot and allied insects.

In Europe, five different species are recorded as parasites on Anthomyiids. In 1834, Bouché enumerated the following: *Alysia ruficeps*, from the pupæ of *Anthomyia radicum*; *Alysia manducator*, from the pupæ of *Anthomyia dentipes*; *Microgaster anthomyiarum*, from the larvæ of *Phorbia ceparum*; *Figites anthomyiarum*, from the pupæ of several species of *Anthomyia*, as *dentipes*, *floralis* (=brassicæ), etc. Taschenberg says: "The small Braconid *Opius procerus* Wsm. was bred from the larvæ by Mr. Brieschke." All of these insects are minute active wasp-like forms, which doubtless crawl into the earth among the maggots and sting their eggs into the bodies of their helpless victims.

Probably none of the above parasites work on the pest in this country; but in 1888 Mr. Gillette discovered that a similar minute Hymenopterous insect was at work on the pest here.

The description of this parasite has not yet been published, but Mr. Fletcher has given it the name *anthomvia*; it is one of the Cynipids belonging to the genus *Trybliographa*, which European authorities consider to constitute a section of the genus *Eucoelis*. In 1893, Mr. Fletcher bred this little parasite in considerable numbers from the puparia of the Cabbage Root Maggot. This year we have bred a few from puparia brought from Long Island. The adult parasite appeared in Mr. Gillette's cage in September from puparia of the first brood found in June. A specimen, recently received from Mr. Fletcher, bore the date, April 15. We bred two of the parasites in August from puparia of the first brood, and an examination of other puparia of this brood to-day (November 6) reveals several which contain no trace of the Cabbage Root Maggot, but instead a broad, fat, much wrinkled, footless, whitish grub that is doubtless the larva of this Cynipid parasite which will probably hibernate in this condition. Probably the eggs of this little foe are laid in the maggot before the puparium stage is reached. In emerging from the puparium, the little wasp-like fly broke through an irregular, nearly square hole just back of the head end.

This little Cynipid has thus been found in Michigan, Canada, and New York, and it doubtless has quite a wider range, possibly occurring in most localities where the maggots work. It may play an important part in keeping this pest in check in the near future.

The little Hymenopterous parasite just discussed has a worthy rival in the form of a small beetle, one of the *Staphylinidae*, or Rove Beetles. Many of these narrow short-winged beetles are very useful as scavengers, some attack living insects, and others are parasites in ant's and wasp's nests. The one which has found the Cabbage Root Maggot very palatable food is very small and slender, measuring only about $\frac{1}{6}$ of an inch in length. The beetle is represented in figure 11, considerably enlarged; the hair line at right shows its natural length. It is black in color, and its body is covered with silky hairs and small punctures. These hairs and punctures being so much less numerous on the head, thorax, and first four antennal joints, cause these parts to appear blacker than the rest of the insect. Sometimes the wing-covers have a greenish coppery lustre. The feet are brown, the femora and tibiae



FIG. 11. — The beetle which preys upon the Cabbage Root Maggot: the hair line at the right represents its natural length. (From Linner)

blackish. The terminal joints of the antennae are so thickly covered with the short hairs as to have a grey appearance.

This little foe received its name, *Aleochara nitida*, in Germany in 1802. There are also frequent references to it in later systematic works by Europeans, thus indicating that it is widely spread and doubtless common in various parts of Europe. It has been known in this country since 1836, when Say described it from Missouri as *Aleochara verna*; this name was made a synonym of *nitida* by Le Conte in 1869. In 1870, Mr. Sprague found the beetle in Massachusetts, and being advised that it was a new species, described it as *Aleochara anthomyiae*, by which name it has since been discussed by American economic writers. However, for nearly ten years, the insect has been considered identical with *nitida* by systematists (Henshaw's List of Coleoptera). In America the insect is now known to occur in Missouri, Massachusetts, New York, and Canada. It thus has a wide distribution both in Europe and in this country.

Nothing seems to have been recorded of the habits of this little beetle until 1870, when Mr. Sprague published the following account :

"I took from the earth in my garden, around the root of a dead cabbage plant, twenty-six pupae of the Cabbage Maggot, from which I bred two imagoes; also six parasites which came out of the pupa-cases by gnawing a rough hole through the side near the extremity, after which I took from the remaining pupa cases three imagoes, and one pupa of the Rove-beetle. My surprise was so great upon discovering the six Rove-beetles where I expected two-winged flies, that I carefully examined with a microscope the remaining pupa-cases, as also those from which the flies came, but could discover no break or orifice by which the Rove-beetles could have entered. It was after this examination that I opened the balance with the above stated results; thus proving, so far as I can judge, that the fly larva was entered before its skin had hardened into the pupa-case."

In 1880, Mr. Barnard found the beetle very abundant here at Ithaca. He says :

"They are often seen running from one young cabbage to another, or entering holes, but more commonly close about the stalk. Half of our young cabbages here, last year and this, have been killed by the maggots, and now on pulling up an infested stalk, these beetles often come out, sometimes several from about one plant. To test their habits, I put a maggot in a bottle with them. When hungry a single one alone will attack a full-sized maggot, tearing open its sides and feasting upon it. I have seen five of them like a pack of wolves, cling to and tear a writhing maggot, killing it quickly. They are wonderfully active, and promise to be the best enemy against the fly which has ruined so many crops here."

Four years ago Mr. Fletcher made the following observations on the habits of this relentless foe of this cabbage pest :

"This little friend . . . was found in considerable numbers running about among the cabbages and burrowing down beneath the soil in search of maggots. Not only is it extremely active in preying upon the maggots, but it is also a true internal parasite feeding inside them and completing its transformations inside the pupa case. In the hope of rearing this beetle, 16 larvae and pupae were taken from the root of a cabbage, where the perfect beetle had been seen and were inclosed in a breeding jar. From these were reared 9 beetles and one fly, the remainder of the pupae dried up without coming to maturity. In some of them, however, the immature beetles were found when the cases were broken. When the beetle eats its way out of the pupa-case it gnaws a ragged hole at one end quite different from that made by the emergence of the fly. . . . I have generally been able to find a few of these beetles in beds of cabbages infested by the Cabbage Maggot and upon one occasion bred a specimen from the Onion Maggot."

These accounts of the habits of this beetle indicate it works destruction to the Cabbage Root Maggot both as a parasitic larva and as a predaceous adult. Both Mr. Sprague's and Mr. Fletcher's accounts would seem to show conclusively that this Staphylinid beetle is a true parasite. And yet, closely allied forms are known to have strictly predaceous habits. In 1883, Mr. Coquillett saw a larva of *Maseochara valida* "busily gnawing its way into a puparium of a Syrphid fly. At the expiration of 24 hours it had completely buried itself in the interior of the puparium, and I saw nothing more of it for a whole month, when it issued through an irregular hole in the upper side of the puparium and soon afterwards spun an irregular, thin, tough, white cocoon in the bottom of the breeding cage. The beetle issued about 11 weeks later." At the meeting of the Association of Economic Entomologists in 1891, Mr. Schwarz, who has a wide knowledge of the habits of beetles, said that he "considered the larva of these beetles not to be true parasites, but simply predatory. . . . and stated, moreover, that the beetle larva has no approach to the parasitic habitus."

Thus theoretically, this enemy of the Cabbage Root Maggot should be purely predaceous in its habits, but practically the evidence of competent observers seems conclusive that it is truly parasitic. As we have not met with the beetle in our observations, we can offer no evidence in support of either opinion. The evidence both pro and con, has been quoted in full, with the hope that it will stimulate future observers to carefully investigate this point whenever they may be fortunate enough to find this little enemy at work. There is no doubt that man has a most potent ally in this little beetle.

The Cabbage Fly has still another enemy in the shape of a mite, a species of *Trombidium*; it resembles its near relative, the

well-known Red Spider so common on house plants. In 1887, this little mite, which would escape detection except by the keenest eyes, was found in Michigan sucking the eggs laid by the Cabbage Fly. It was found that three of the mites would suck, on an average 28 eggs every day. No similar observations have since been recorded.

Thus, in this country, man is aided in his warfare against this most formidable cabbage pest by the chickens, by at least two common and widely distributed foes among its own kind as the Staphylinid beetle and the little Hymenopterous parasite, and by a mite. However, these foes apparently have not yet gained sufficient strength to effectively check the Cabbage Root Maggot in its destructive work. The time may come when the balance of nature will turn in favor of these little foes. Thus the gardener needs to be acquainted with these little friends of his that he may protect them whenever they are found "lending a hand."

METHODS OF PREVENTING THE RAVAGES OF THIS PEST.

About 70 different methods have been recommended for combating this pest. Our experiments and a study of recorded experiments, lead us to believe that only 6 of these need be, at present, seriously considered by gardeners. They are therefore discussed first, in large type, as the Effective methods, two of which act as preventives, and the others are used to destroy the insect.

We group 9 of the proposed methods as Doubtful, or Partially Effective; 3 of these are preventives of attack, and 6 act destructively.

The remaining methods, about 50 in number, we class as Ineffective, or Impracticable methods, about one half of which are supposed to be preventive in their action, and the others destructive. Some of these deserve further notice by future experimenters.

This full discussion of all methods recommended to combat this pest will enable gardeners and others to decide *what not to use, what is worthy of a trial, and what methods have been found practicable and effective.*

I. EFFECTIVE METHODS.

A. PREVENTIVE.

1. BY MECHANICAL DEVICES.

(a) *Covered Frames over Plants.*

This method of growing the plants, either in a cold frame covered with cheese cloth or fine netting, or under a similar protection in the field, is of course, only practicable with small areas or a few choice plants. Prof. Cook grew radishes successfully in this manner in 1888. Wherever practicable it will prove a sure preventive, but must be applied early before the flies appear and be kept on during nearly the whole season.

(b) *Tarred Paper Cards.*

This idea of preventing the attacks of the Cabbage Root Maggot by closely encircling the stems of the plants by paper collars resting upon the ground, first originated in Michigan in 1887. Prof. Tracy, of Detroit, experimented with heavy manilla paper, but not with satisfactory results. Prof. Cook also experimented with the paper cards, and although he secured hundreds of eggs where he used adhesive fly paper for the cards, yet he could not recommend the method; he seems not to have tested it again.

In the spring of 1889, the idea occurred to Mr. Goff to substitute for the manilla paper, cards made of tarred paper, and further protection was secured by the use of a bit of grafting wax to form a more perfect union between the paper and the stem. His experiment was a complete success.

This preliminary experiment was so successful that the next season Mr. Goff perfected the method by devising a very simple tool which would cut, at a single operation, a six-sided card with a slit reaching to the center, and with a star-shaped cut at the center so that the same card may accommodate itself to any sized stem and still make a tight joint. He had these cards tested by several large cabbage growers that season. Mr. J. M. Smith, of Green Bay, Wis., reported that he had about 7,000 plants protected with the cards and secured a splendid crop; while a like number of unprotected plants nearby would have been an entire failure if he had not resorted to the hand-picking of the maggots. Messrs Smith Brothers of the same place also reported a like success from the use of the cards. In 1891, these same parties again used the cards. The former reported that he lost from the maggots not more than 25 plants of the 10,000 to 15,000 that he protected with

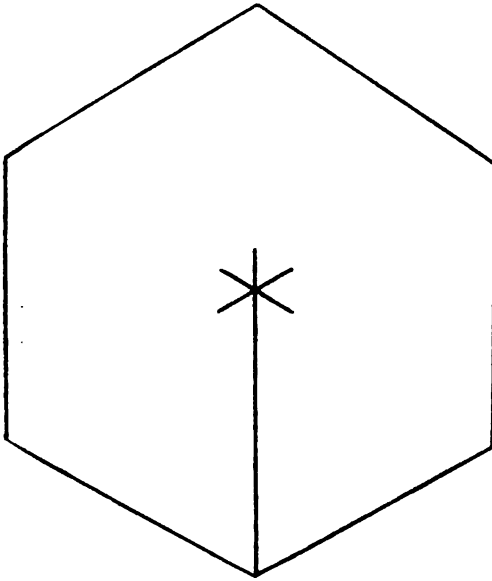


FIG. 12.—Outline of Tarred Paper Card; natural size. (From Goff.)

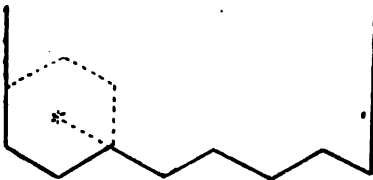


FIG. 13.—Diagram showing how the tool is used. The dotted line indicates the position of the edge of the tool. (From Goff.)

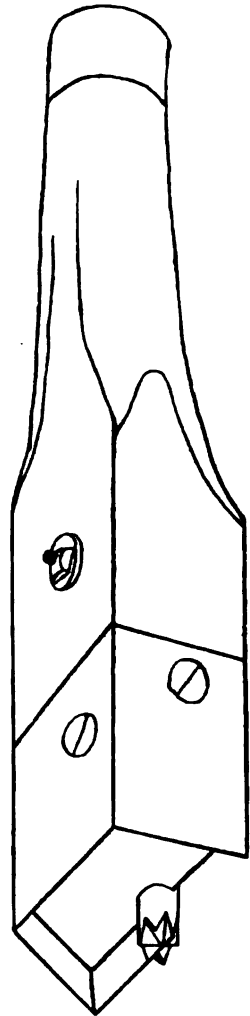


FIG. 14.—Tool for cutting the cards; about $\frac{1}{2}$ natural size. (From Goff.)

the cards; ordinarily he would have lost from $\frac{1}{4}$ to $\frac{1}{10}$ of the crop. Messrs. Smith Brothers used about 15,000 of the cards and had no maggots, except where the cards were not properly put on.

These experiments having established the practicability of the tarred paper cards, the method was published by Mr. Goff in 1891. We have reproduced Mr. Goff's outline drawings of one of the cards (Fig. 12) natural size, of the cutting tool (Fig. 13) about $\frac{1}{2}$ natural size, and of the diagram showing how the tool is to be used (Fig. 14) much reduced. We quote Mr. Goff's concise descriptions of the cards and tool, and their use: "The cards are cut in a hexagonal form, in order to better economize the material, and a thinner grade of tarred paper than the ordinary roofing felt is used, as it is not only cheaper, but being more flexible, the cards made from it are more readily placed about the plant without being torn.

"The blade of the tool, which should be made by an expert blacksmith, is formed from a band of steel, bent in the form of a half hexagon, and then taking an acute angle, reaches nearly to the center, as shown in figure 14. The part making the star-shaped cut is formed from a separate piece of steel, so attached to the handle as to make a close joint with the blade. The latter is beveled from the outside all around, so that by removing the part making the star-shaped cut, the edge may be ground on a grindstone. It is important that the angles in the blade be made perfect, and that its outline represents an exact half hexagon.

"To use the tool, place the tarred paper on the end of a section of a log or piece of timber and first cut the lower edge into notches, as indicated in figure 13, using only one angle of the tool. Then commence at the left side, and place the blade as indicated by the dotted lines, and strike at the end of the handle with a light mallet, and a complete card is made. Continue in this manner across the paper. The first cut of every alternate course will make an imperfect card, and the last cut in any course may be imperfect, but the other cuts will make perfect cards if the tool is correctly made, and properly used.

"The cards should be placed about the plants at the time of transplanting. To place the card bend it slightly, to open the slit, then slip it on to the center, the stem entering the slit, after which spread the card out flat, and press the points formed by the star-shaped cut snugly around the stem." At *a* in figure 16 is shown a card properly applied to the stem of a geranium; *b* shows a card carelessly put on.

Mr. P. J. Diepold of Madison, Wis., has made several of the cutters; he charges \$2.50 each, and makes a very satisfactory tool. The best grade of paper to use is what is termed "one ply tarred felt." It can be bought in retail lots for from 2 to 4 cents per pound. The following letter published by Mr. Goff gives reliable data as to the cost of the cards, the labor of applying them on a large scale, and other useful hints:

GREEN BAY, Wis., April 12, 1894.

Our young man cuts from 500 to 600 of the cabbage pads per hour or 5,000 to 6,000 per day of ten hours. One person will put on from 300 to 500 per

hour according to the rapidity of the workman. The paper that we use costs from $1\frac{1}{4}$ to $1\frac{1}{2}$ cents per pound at wholesale, or from $2\frac{1}{2}$ to 3 cents at retail, and one pound makes about 200 pads. In giving instructions to anyone in regard to using the pads, always caution them about getting the pads too low down, for if they are covered with enough earth so that the earth above the card remains moist, the maggots will work over the pads. We had one bed of cabbage two years ago that illustrated this point in the most perfect manner. The bed extended from ground that was quite firm to some that was very soft, and in the soft part the boys set the plants too low and the earth gathered in over the pads and the maggots got their work in according to the amount of earth there was over the pads. On



FIG. 15.—*An arrangement for facilitating the cutting of the cards.*

this same bed I made an experiment without and with the pads and the result proved, as it had before, that beyond all question the pads do all that we have claimed for them.

GEO. B. SMITH.

Mr. Smith has described for us his arrangement for cutting the cards. He says: "We put the roll of paper on a roller made by standing two pieces of plank up edgewise to the wall, fastening

them in position, and boring an $1\frac{1}{2}$ inch hole in each; a hoe handle put through the hole in the roll of paper, serves as a roller. The cutting block is made wide enough to work the whole width of the paper by fastening several blocks of hard wood together; it is then stood on end immediately in front of the roller." This arrangement is shown in figure 15. Where large numbers of the cards are to be cut, some such device would facilitate the work very much.

Being very favorably impressed with this preventive method devised by Mr. Goff, we planned to further test it on our experiment plot on Long Island. A diagram and description of this plot is given on page 551. The diagram represents the rows on which we planned to put the cards. They were put on April 19, the day after the plants were set. Mr. Reeve, the owner of the plot, applied the cards quickly and quite well for one with no previous experience. May 21, we examined the plot. It required but a glance over the field from the west end to determine which rows had been treated with the preventives, and especially was this true of those protected by the cards. However, as we glanced along the 4th, an untreated row, and the 5th, a treated row, it soon became evident that either the cards had offered but little protection to the plants in the east half of the latter row, or that we had not followed the plan. For the east half of the 4th row, which should have had but few plants standing, judging from the other untreated rows, showed nearly all the plants in good condition. Further examination showed that we had made a mistake and the cards had been applied to the east half of the 4th row instead. Thus the preventive experiments were planned as in the diagram on page 551 but were applied according to the following diagram:

NORTH.		
West.	1st row : Tobacco Dust	Paper Pads.
	2d row : untreated	untreated.
	3d row : Paper Pads	Carbolic Acid Emulsion.
	4th row : untreated	Paper Pads.
	5th row : Carbolic Acid Emulsion.	untreated.
	6th row : Paper Pads	Tobacco Dust.
SOUTH.		
East.		

This mistake only served to bring out more strongly the effectiveness of the cards.

When the examination was made (May 21), the maggots had done their worst, and scarcely 50 plants remained standing in the untreated rows, while less than 50 had succumbed in either of the two rows protected by the cards. We found a few maggots on some apparently healthy plants that had the cards. Thus the cards had not been a complete success, but they had saved more than we had expected from the conditions under which they were applied. The pest appeared in such numbers as to severely test any method

that might be devised to combat them. The soil was also very loose and uneven, and had been cultivated into ridges in which the plants had been set; and we purposely had the cards put on with only the care that an inexperienced person would take. Although the conditions were thus against the success of the method, yet Mr. Reeve reported in August that he had cut 327 heads from the two rows on which the cards were put; the west half of the 3rd row gave 77 heads, and the west half of the 7th row 60 heads (chickens had destroyed about 25 plants on the end of these half rows); from the east half of the first row he had cut 100 heads, and from the east half of the 4th row 90 heads. The two untreated rows together produced but 90 heads.

The experience of Mr. Smith given in his letter above, well illustrates the importance of proper conditions and proper care in



FIG. 16.—a, *Tarred Paper Card properly put on*; b, *a card carelessly applied that will not prevent.*

applying the cards.

He also writes us on this point: "If the soil is very light and loose, care must be taken that the plants are not pressed down too deeply so as to form a cup or dish around the plant. .

. . . If the land is very soft, the better plan would be to roll it before setting the plants." To further impress the idea of properly putting on the cards, we have

introduced figure 16 which shows a card properly applied at a; and one carelessly put on at b, under which a female fly could easily crawl and lay her quota of eggs near the stem. With a little practice, the cards can be applied properly just as easily and as quickly as it can be done carelessly. Growers will soon learn, as have Messrs. Smith Brothers of Wisconsin, that the cards, to be effective, must be properly applied; and that when the cards are thus applied, they are very effective.

Our experience satisfies us that these cards will afford almost complete protection to cabbages and cauliflowers from the Cab-

bage Root Maggot, if a little care is taken in applying them. The protection evidently comes, not from the smell of the cards tending to drive away the fly, but from her inability to get to the stem to lay her eggs. The experience of the Messrs. Smiths at Green Bay shows that the cards are practicable on a large scale. Messrs. Smith Brothers wrote us they cut 20,000 for use this year; it costs them for material and labor about \$1 to protect 1,000 plants. No second treatment is required; sometimes a little care is necessary in hoeing, so as not to cover the cards with dirt. In our State it will not be necessary to use the cards after May 20. They will not last more than one season, but new ones can be made during the winter when other work is not so pressing. Most of the Long Island gardeners with whom we discussed the method were favorably impressed with it, but some of them set their plants so deeply that it would not be practicable to properly put on the cards. The plants are set so deeply that the bases of the first 2 or 3 leaves are below the surface. Of this method of setting, Prof. Bailey says (Bull. 37, p. 405, of the Cornell Agr. Expt. Station): "We find as a result of three years' investigation, that the depth at which strong and stocky cabbage plants are set does not influence the extent or weight of the crop."

Therefore, we believe that gardeners will find that this method, which is unfortunately only applicable to cabbages and cauliflowers, will prove, when properly carried out, the cheapest, most practicable, and most efficient method yet devised for preventing the ravages of the Cabbage Root Maggot. However, the same objection may be raised against it as would apply to any preventive method; that is, it must be kept up for several years as the experience of Messrs. Smith Brothers shows. Our discovery that the pest breeds freely on several common weeds offers a reasonable explanation why this is true. If all of the Cruciferous weeds in the neighborhood could be exterminated and none of its other cultivated food-plants be grown unprotected near by, then a few years of prevention with the cards would doubtless starve out the pest in that locality.

B. DESTRUCTIVE MEASURES.

1. DESTRUCTION OF THE EGGS.

In 1879, Mr. Philbrick recorded that "the only effectual remedy he ever heard of is rubbing, with the fingers, the stem of the cabbage every few days to destroy the eggs and young maggots." Mr. H. A. March writes in 1887 that "he watches the flies carefully in the spring, and after they have been at work 4 or 5 days, he hires women to go along and rake (with a tool made for the purpose) all the eggs into the middle of the row where they dry up or the maggots cannot get to food; if any maggots are found they are at once crushed. The eggs are readily seen with keen eyes. The field is gone over again in a week, with the result that less than 5 per cent. of the plants are lost." In commenting upon Mr. March's account, Mr. Henderson says (*Rural New Yorker* for 1887, p. 578): "In my opinion it is the only thing that can be done to save the crop when the maggots are present. We adopted the same plan several years ago and have been comparatively free since."

This evidence shows that the method is practicable and efficient. Our experience with the eggs, as mentioned in the discussion of the oviposition of the insect, indicated that the eggs failed to hatch when much disturbed. Either Mr. Philbrick's or Mr. March's method would be effectual, and the only expense is the labor. The practicability and effectiveness of the method should recommend it to all gardeners.

2. DESTRUCTION OF THE MAGGOTS.

(a) *By Hand-picking.*

As is indicated in the correspondence included in the discussion of the Tarred Paper Card Preventive, some gardeners resort to hand-picking of the maggots to save their crop. It must be a laborious method, but has the merit of being very effective. It would seem, at first thought, hardly profitable on a large scale, and yet when we realize that oftentimes it means a loss of the entire crop if the maggots are not removed, then the method becomes practicable. Mr. Fletcher found in 1887 that cabbage plants may even be taken up, the roots examined, perhaps washed in strong soap suds, replanted, and yet after 2 or 3 weeks show no differences from uninfested plants which had not been disturbed. Thus, hand-picking is sure to be effective, is always practicable on a

small scale or with choice plants, and is practiced sometimes by extensive cabbage growers with profit.

(b). *By the Use of Insecticidal Substances.*

Carbolic Acid.

Since 1881, when Prof. Cook first tested this substance, it has been used with quite uniform success by other investigators; but all have considered that its effectiveness was due to its odor, which prevented the flies from ovipositing on the plants treated with it. Mr. Fletcher says: "It must, however, be remembered that it is a 'preventive' of attack, not a 'remedy' for application after the attack has begun. It is for keeping the flies from coming to lay their eggs. When used as a remedy to destroy them it would have to be of such a strength as would destroy the plants also." He then quotes from Prof. Hilgard to show that "a solution of carbolic acid, that would be instant death to an insect sprinkled with it, becomes inodorous and harmless when filtered through a few inches of soil." Our discussion of this substance as a preventive, on page 552, should be read in this connection, for it includes the results of the experiments which have been made with the acid.

While applying the substance in our experiments there recorded, we found that it quickly soaked into the ground, leaving but little odor after a few hours; and we thus expected but little result from its use. But the results recorded in the preventive discussion of this substance show that it was quite effective, but was not so effective as the Tarred Paper Cards; and yet the much stronger, but similar, odor of the cards was not what gave the protection, for wherever not properly applied the flies crawled under and accomplished their object. It is also a significant fact in this connection that, in all of the experiments by Mr. Fletcher and Prof. Cook, although the applications were doubtless begun before any eggs were laid, yet the applications were continued either until the plants were large enough to eat or until after the time for the maggots to appear. We are therefore inclined to believe that most of the good results heretofore gained by the use of this substance have been through its killing power, either on the egg or maggot, rather than from its having had any preventive effect on the flies.

The following laboratory experiments show that it has decided killing powers. May 25, 10 small maggots, brought from Long Island, were put at the base of each of two well-established cabbage plants. The next day, after the maggots had begun work on the plants, the earth was removed from about the base of the plants until some of the maggots were laid bare. Then around one plant was poured 4 oz. of an emulsion (1 lb. soap, 1 gal. water, and $\frac{1}{2}$ gal. crude carbolic acid) diluted with 50 parts of water, or at the rate of a pint of acid to about 22 gals. of water. Around the other plant was poured 4 oz. of the same emulsion diluted with 75 parts of water. May 30, this latter cage was superficially examined, with the result that 30 dead and 3 living maggots, and 14 puparia were found; many of the dead maggots

were found underneath the bark of the root in their burrows, while nearly all the live maggots seen were on the lowest roots where perhaps the emulsion had not penetrated. The puparia were replaced. June 7, both cages were carefully examined. In the one examined May 30, 8 of the puparia were still alive, but no live maggots were found. In the cage where the emulsion was applied in a 50 part dilution, many dead maggots, 12 dead and 12 apparently live puparia, were found; no live maggots remained. In similar cages which received no treatment, from 71 to 95 puparia were found. The killing power of the emulsion was thus very evident, and the 75 part dilution seemed equally as effective as the 50 part. In fact, this emulsion gave the most promising results of anything we tried here in the insectary, except the bisulphide of carbon treatment described later. None of the plants showed any injury from the application. The same amount of the emulsion was applied to other plants, about large enough to set in the field, but which had no insects on their roots; and no injury had resulted from the applications 20 days later.

Thus, our experience, both in the field and in the insectary, lead us to believe that in this emulsion we have one of the cheapest, most effective, and most practicable killing agents that has yet been suggested for combating these root maggots. The material can be easily and cheaply obtained, so that the principal expense is in its application. Always use the *crude* carbolic acid as it is much cheaper than the purified and is nearly, if not quite, as effective. It will probably be safer if used as an emulsion than if simply diluted with water. We would advise that it be made by the following formula: 1 lb. of hard soap or 1 qt. of soft soap dissolved in 1 gal. of boiling water, into which 1 pint of *crude* carbolic acid is then poured and the whole mass agitated into an emulsion, which will remain in this condition for a long time. In treating the plants, take one part of this standard emulsion and dilute it with 30 equal parts of water; it probably can be used stronger without injury to the plants. If the emulsion is cold and semi-solid use several parts of warm water at first. Begin the treatment early, a day or two after the plants are up, or in the case of cabbages and cauliflowers, the next day after they are set in the field, and repeat it once each week or ten days until about May 20 in our State. While we have little faith in the preventive effects of the early treatments, we do believe that the emulsion will then kill many of the eggs and recently hatched maggots. If it could be applied with some force through a syringe or force pump, it might not be necessary to go to this trouble of

first removing some of the earth from about the plants. It must be remembered that its success will depend on the eggs or maggots being hit with it. None of the cabbages in our experiment were injured in the least by an application containing nearly twice as much of the acid, and there is but little danger of its injuring the tenderest foliage of radishes, turnips or onions ; if any injury manifests itself on these crops, dilute the emulsion with 40 or 50 or more parts of water, instead of 30. A Knapsack or a Wheelbarrow sprayer would prove a very useful instrument in applying the emulsion on a large scale.

Whoever has tried this emulsion thoroughly report success, and we believe it is the most successful and most practicable method of treating radishes, turnips, or onions, yet devised ; for plants of the cabbage tribe, other methods discussed further on will prove more effectual. We hope this emulsion may be given a fair trial by many gardeners and other investigators. In our experience, it is more effective than the kerosene emulsion and rivals the bisulphide of carbon treatment.

CARBON BISULPHIDE.

Prof. Cook was the first to experiment with this volatile substance on the root maggots. In 1880, he used it for this purpose "with the happiest results. A small hole was made in the earth near the main root of the plant, by the use of a walking stick, and about 15 cubic centimeters of the liquid poured in, and the hole quickly filled with earth, which was pressed down with the foot. In every case the insects were killed without injury to the plants." The next year, Prof. Cook found that its use was not practicable in radish beds owing to the great number of plants to be treated, thus requiring so much liquid as to make it an expensive treatment ; he tried making a few applications at short distances apart in the bed, but not with satisfactory results. In 1884, some of Prof. Cook's correspondents reported that the substance sometimes injured the cabbage plants, and its efficiency varied with the nature of the soil. The same year, Mr. Goff "found that bisulphide of carbon applied to the soil about the roots of radishes, destroyed the maggots that had not yet entered the root, but it had no perceptible effect upon those within."

In 1886, Prof. Cook reported before the Ingham Horticultural Society that experiments at the College that year had showed conclusively that, if carefully applied and used in time, it was a specific against the maggots. Those who had reported that

it would not do effective work in clay soil, or that it killed the plant, had, without doubt, deferred the application till the plants were beyond hope. A Mr. Lee, in the audience, said he had tried the liquid, and knew it would always work on clay or sand, and not hurt the plants. *He made a hole a little way from the plant.* We italicize this sentence, because it is the keynote of success with this substance. We believe that most of the reported injury to the plants has been due to the hole having been made close beside the plants so that the liquid itself reached the roots. The liquid would very quickly kill the root, but its vapor would do no harm. This point is more fully emphasized later on.

The following year, however, Prof. Cook says he is persuaded, after a thorough trial, that this substance cannot be made practicable. Differences in soils, and seclusion of the maggots which bore quickly out of reach of the insecticide, make its use uncertain, and therefore unsatisfactory. In 1883, Mr. Hulst reported that the substance could not be used, for when it came in contact with the roots it always did them very great injury. In 1892, in response to an inquiry from Mr. Barnhardt, the U. S. Entomologist advised him to try the liquid. Although the application was made (June 15) after many of the maggots had changed to puparia, he reported very satisfactory results.

From the above brief resumé of the experiments thus far reported with this substance, we glean that the weight of evidence shows that it can usually be depended upon to kill the maggots. The only serious objections raised are that it sometimes seems not to work alike in all soils; also, it may injure the plants; and such large quantities would have to be used on radishes, onions, or turnips as to make it expensive and thus not practicable on these crops. The last objection is doubtless a valid one, unless the plants are of a choice or new variety. However, we believe, as did Prof. Cook and Mr. Lee in 1886, that when properly applied, it will prove very effective against the maggots on any soils without injuring the plants; of course, it will work slower somewhat on the heavier soils, and the dose may have to be increased slightly on such soils.

A few preliminary experiments in cages here at the insectary with this substance showed that it killed, not only the maggots, but the puparia also. Scarcely a live insect could be found in the cages the next day after applying a teaspoonful of the liquid to each plant. Ten puparia were placed beneath the soil in each of two cages, and to one cage a teaspoonful of the

liquid was applied and the other was left untreated. No flies ever emerged in the treated cage, while nearly every one of the puparia gave out a fly in the untreated cage. In no case did the plants show any signs of injury from the liquid. We always applied the liquid in a horizontal hole beginning about three or four inches from the plant and running down to a point a little below the roots.

But while our experiments demonstrated that the substance was sure death to the insects and did not injure the plants, we were convinced that to make the method practicable in the field, some method must be devised by which the liquid could be more quickly, safely and perhaps efficiently applied.

It seemed as though some instrument might be, or possibly had already been, devised by which the liquid could be thus applied. We were unable to find any record of such an instrument having been devised in this country. The "Pal-injecteur" used in France is also too extremely heavy and clumsy, and very expensive.

The instrument devised by Prof. Cook in 1884, for the underground application of kerosene emulsion, apparently could not be adapted for the use of the bisulphide of carbon. Mr. Barnard's "Nether-inserter," devised in 1883, facilitated the making of the hole, but not the application of the liquid. Thus no instrument seemed to have been devised by which the application of the liquid could be made practicable in cabbage or cauliflower fields.

The case was stated to Mr. McGowen, the inventor of the famous McGowen Spray Nozzle. After several experiments in trying to simplify the French instrument, the idea was abandoned. He then started out on a theory of his own, and finally devised an instrument which seems to "fill the bill" quite completely. In honor of the inventor, we shall call it "The McGowen Injector." In construction, it is very simple, as the sectional drawings in fig. 17 show; the description of the different parts, and how they work are given below.

Description of the McGowen Injector.—Figure 17, *B*, represents a sectional view of the instrument, about one-seventh natural size. It consists of a long piston, *p*, its upper portion working closely in a small cylinder; the middle portion passing through the long reservoir, *r*; and to the lower smaller portion which passes through that part of the instrument, *g*, which is forced into the ground, is attached the valves, *v*, working in a cylinder attached to the lower end of the reservoir. A handle is attached to the upper

end of the piston, and the lower end is pointed and works closely in the lower small cylinder only at the point opposite *g*. The reservoir is filled through the opening at *e*, which is protected by a screw cap. In *B*, the instrument is ready for insertion in the soil. At *A*, is shown a section of the lower portion of the instrument, nearly one half natural size, and this view represents the position of the valves, *v*, when the instrument is being withdrawn from the soil. It operates very simply. When the piston is pulled up it is stopped at the proper point by the metal pin through the piston near *p*, in *B*. This brings the upper valve into the reservoir, *r*, and the liquid immediately fills the chamber between the two valves; this is the measuring chamber, and its size can be easily regulated to hold a teaspoonful, or more or less, by simply screwing the valves either way or by winding cloth around the piston between the valves. Before inserting in the soil, the piston is pushed down and is stopped by the lower valve striking against the bottom of its cylinder. The valves are then in the position shown in *B*. As the lower portion of this valve cylinder is cut out larger, the liquid escapes into this lower chamber, *l. c.*, and some runs down around the lower part of the piston but is prevented from escaping by the arrangement near the point, at *g*, by which the piston here fits very closely. The pulling up of the piston again, of course, lets the charge of liquid run out, and at the same time the measuring chamber is again filled, thus securing an automatic action. It was found necessary to have an opening in the lower chamber, *l. c.*, in order to allow air to take the place of the liquid so it could freely run into the soil. This opening, *o*, also supplies the measuring chamber with air which is drawn up into the reservoir and then displaces the liquid and allows it to freely enter the measuring chamber. All parts of the instrument are made of brass, except the small discs or leather in the valves, and the wooden handle on the piston; the reservoir may be made of tin. All parts must fit closely, for the liquid works through where water would not. The reservoir can be made larger or smaller, and the lower portion which is inserted in the ground can be made of any length to suit the depth to which it may sometimes be necessary to apply the liquid. On larger instruments a foot-rest could

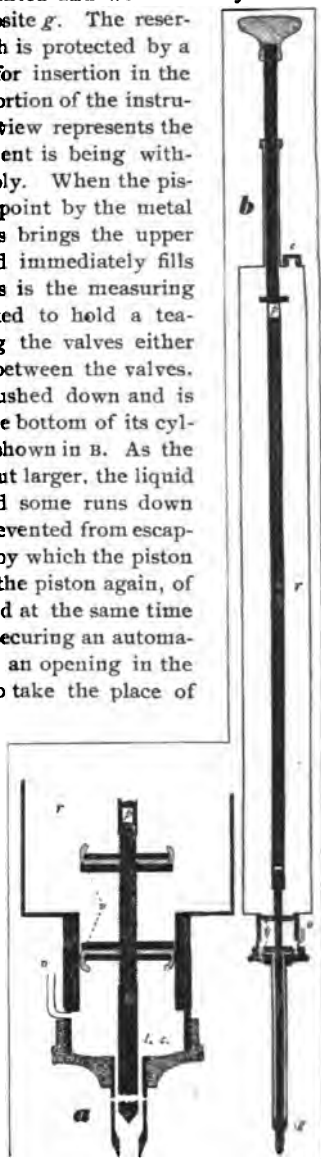


FIG. 17.—The McGowen Injector.

be easily attached to assist in inserting the instrument if necessary. The reservoir in our instrument (Fig. 18) is 2 feet long, $2\frac{1}{2}$ inches in diameter, and holds 2 quarts of liquid.

All the parts of the injector are made of brass or tin except the simple discs of leather used in the valves, *v*. These can be easily replaced when worn. The price at which it can be made and sold will depend upon the demand and also on its size and the material of which the reservoir (*r*) is made, whether tin or brass. The reservoir in the one shown in operation in figure 18 is 2 feet long, $2\frac{1}{2}$ inches in diameter, and holds about 2 quarts of the liquid. This is about the right size for use against the Cabbage Root Maggot, as one filling of the reservoir will treat about 500 plants, using a teaspoonful at each plant. It could easily be made larger without adding much weight to the instrument, for a slight increase in the diameter of the reservoir would greatly increase its capacity. Mr. McGowen can make them any size desired. The one shown in figure 18 can be made for from \$3 to \$5, depending on the demand for it and the material used; in large quantities, they could doubtless be made for less. The brass instrument we have has a capacity of 2 quarts and weighs when empty $4\frac{1}{2}$ pounds, and when full of water 4 pounds more. Thus in gardens it will require but little more than the weight of the loaded instrument to force it into the soil. But if a larger instrument was needed it might be well to have a foot-rest attached near the bottom.

In fact, we believe the instrument can be so adapted as to work satisfactorily wherever the liquid is now used against underground insects. For instance, it will facilitate the application of the liquid to the new Grape Root-worm. (*Fidia viticida*) which has recently appeared in Ohio; and it is possible, as Prof. Cook suggested in 1880, that the Peach Borer (*Sannina exitiosa*) may be killed by the substance, especially on small trees where it works almost entirely on the roots (we shall try some experiments in this line in the spring). Many other instances might be mentioned where it would be practicable to use the liquid, now that we have a suitable instrument to apply it. In fact, this simple and cheap injector should open up a whole field of experimentation with this liquid; why not use it against the root form of the Black Peach Aphis (discussed in Bulletin 49) or the Wooly Aphis of the apple.

The liquid is very volatile and will thus quickly evaporate if

left in an open or uncorked vessel ; we find large glass bottles with tight-fitting corks the best receptacles for it. The vapor is very poisonous and great care should be taken in pouring it out not to breathe much of it. As the vapor is also very explosive, no lights of any kind should be brought near when it is being used. Treat it with more care than you would gunpowder, in this respect. The best and cheapest brand now on the market is that known as "Fuma Carbon Bi-Sulphide," manufactured by Edward R. Taylor, Cleveland, Ohio. He ships it in 10 lb. cans at 12 cents per pound, or in 50 lb. cans at 10 cents per pound. It can be obtained in small quantities at drug stores, but usually for not less than 25 cents per pound.

Thus cabbage plants can be treated once, and once is usually sufficient, at the rate of about 10 plants for 1 cent for the liquid, using about 1 teaspoonful to each plant. As the injector will last for years, and several neighbors might join in the purchase and use of one instrument, its cost would practically not influence this estimate of the cost of killing the maggots. We believe it is the cheapest, most effective, and most practicable method yet devised for fighting this pest on crops of cabbages and cauliflowers ; on crops of radishes, turnips, or onions it will probably be too expensive except where choice or new varieties are attacked. The Carbolic Acid Emulsion will prove the most practicable on these last crops.

The method of inserting the injector is shown in figure 18. The hole should always begin at a distance of 3 or 4 inches from the plant and run horizontally downward to a point a little below the roots. To accomplish this, the injector must be inserted at an angle as shown in the figure. Force it down until you think the point is a little below the roots, then let out the charge of liquid. In operating the injector, first pull the piston up as far as it will go ; this loads the measuring chamber between the valves ; then push down the piston until it stops, and the instrument is ready to be pushed into the ground. Push it into the ground as far as desired, hold it there while you pull up the piston ; by this operation you let the charge out of the lower chamber into the ground, and at the same time the measuring chamber is again filled. Hold the injector in the ground a few seconds after the piston has

been pulled up in order that all the liquid in the charge may have a chance to run out. Then pull the injector out of the ground, and quickly, with the foot, fill the hole with earth and step on it to pack it down. Press down the piston, and you are ready to treat the next plant. Never push the injector in the ground unless the piston is clear down, because if the lower end is not thus closed, it will immediately fill with soil which is not easily removed. Study the drawings in figure 17 in connection with these directions and you will understand the reason for each step. We would advise that the reservoir be first filled with water and the injector operated above the ground until each step is thoroughly understood. There is nothing complicated about the instrument, or the way it is to be operated. It can be easily taken apart and cleaned if necessary; the only caution to be observed in replacing the parts is to have the flanges of the leather in the upper valve turned upward.



FIG. 18.—*The McGowen Injector, and how to use it.*

We recently tested the effect of the liquid on some young cabbage plants not yet large enough to set in the field. A table-

spoonful of the liquid was applied beneath several plants with the injector. In a few minutes the odor of the liquid was very noticeable on the surface around the plants. These plants have not showed any signs of injury from this large dose. As stated in the description of figure 17, the amount of liquid to be applied can be easily regulated. On small plants, a teaspoonful will probably be sufficient. When the plants are well established in the field, and the maggots thick, use a tablespoonful. One application will usually suffice. The time to apply will be when the maggots are first discovered, early in May. Do not wait until the plants begin to wilt before making the application, for although it will then kill the insects, it will not reinvigorate the plant.

We believe gardeners will find this the most practicable and most effective method of killing the Cabbage Root Maggot when it attacks cabbages and cauliflowers.

2. DOUBTFUL, OR PARTIALLY EFFECTIVE METHODS.

With some gardeners, many of these methods may prove quite effective; in fact some have used them with apparent success. However, we believe that they should be more thoroughly tested before they are unqualifiedly recommended for indiscriminate use by gardeners.

A. PREVENTIVE.

1. *Substances Applied to the Soil.*

Gas Lime.

Doubtless the vile-smelling properties of this refuse from gas works, is what suggested its use as a preventive of the Cabbage Fly. However, evidence accumulates every year that vile smells are not so obnoxious to insects as was thought several years ago. Prof. J. B. Smith showed (Bull. 75, N. J. Expt. Station, p. 29) that gas-tar has no repellant effect on the Squash Borer. He also says (Bull. 85, p. 8) that "it is important to know that what we consider as foul or vile smells never yet kept away insects. . . . It is not the smell of gas lime, but the caustic properties that are of value" Mr. Lazenby found (Mich. Hort. Soc. Report for 1881, p. 214) that gas-lime did not effectively repel the Codlin Moth.

The first record we find of the use of gas lime to prevent this pest, is by Mr. Garfield in 1877. He treated alternate rows of radishes and turnips with the substance, "hoping by means of a vile odor to prevent the flies

from laying their eggs." He reports it a failure. In England gas lime is extensively used by gardeners, and Miss Ormerod reports some favorable testimony for it as a preventive; none of the evidence is conclusive, however. In Canada, Mr. Fletcher reports good effects from putting a small quantity of fresh gas-lime around each Cabbage plant when setting it out; on radishes or onions it had to be applied at frequent intervals, and was then not an infallible remedy. Mr. Wright Rives, of Washington, D C., writes us that the cabbage growers near Beltsville, Md., use large quantities of gas lime yearly, and they report good results from it.

Thus, there is but little definite evidence either for or against the effectiveness of gas lime as a preventive. It cannot be readily obtained in many localities, and is liable to injure the plants if used when too fresh or in too large quantities. Wherever it is practicable it should be tried, although we are inclined to doubt its efficiency.

2. *Cultivation.*

Whatever method is employed in growing the crop seems to have but little preventive effect on the insect. It is true that often a much larger crop is produced in an infested field if the soil is kept well hilled up around the plant. In this case the difference is not due to the lessening of the numbers of the pest, but the plant, thus encouraged, sends out enough roots for both itself and the maggots. However, we believe that the numbers of the pest can be materially lessened for the next season by following the infested crop with some crop which the pest does not attack. This crop should be one requiring frequent cultivation so as to keep down all Cruciferous weeds, some of which we now know would harbor the pest. Also, if all the remnants of the crops upon which the pest feeds, as the cabbage "stumps," etc., are thoroughly removed and destroyed in the fall, we believe many of the insects will thus be destroyed. Thus, clean culture throughout the season will, we believe, materially lessen the numbers of the pest appearing next spring, and thus act as a preventive.

3. *Kerosene Oil and Sand.*

In 1885, Mr. Fletcher reported that he had good success in preventing the attacks of the pest on radishes by sprinkling sand saturated with kerosene (a large cupful to a pailful of dry sand) along the rows once a week until they were large enough to thin out and have the ground well hoed over the roots. He also reports good results from its application every week until the middle of July around the stems of cabbages. This simple method is practicable, on a small scale at least, and should be tried by gardeners, for all the evidence yet reported favors it.

B. DESTRUCTIVE.

1. DESTRUCTION OF THE MAGGOTS.

(a) By the Application of Direct or Indirect Fertilizers.

Lime and Liquid Manure.

The recommendation of this combination rests upon the experiment of Mr. Dunning in 1839. He found on May 20 that some early cauliflowers were badly infested by the maggots; the stems below ground were entirely encased in maggots. The next day he applied to each plant a pint of a mixture formed by slacking 5 pecks of fresh burned lime in 100 gals. of liquid manure; this was stirred ten minutes and poured around the plants with a sprinkler. From an examination of a dozen plants on May 27, he reports that not a live maggot could be found, and the plants had made a large amount of new roots. When he used gas lime instead of ordinary lime, the effect was not so good. He states that the lime water killed the maggots and the manure stimulated the roots. Where liquid manure can be obtained in such quantities, this combination should be tried. Judging from Mr. Dunning's report, this is one of the most promising recommendations yet made to combat the pest. We hope it may soon be further tested.

(b) By the use of Insecticidal Substances.

Hellebore.

In his report for 1890, Mr. Fletcher recorded the first experiments with this substance against the Cabbage Root Maggot. Some 3 years before he had learned that one of his correspondents had used a decoction of it with considerable success on the Onion Maggot. Mr. Fletcher applied the substance to about 1,200 plants in the following manner: "One person carried a 3-gallon pailfull of water in which 2 ounces of white hellebore had been steeped, and an ordinary green-house syringe, the other placing the left hand beneath the cabbage, palm downwards with two fingers on each side of the stem, drew away the surface soil from the root of the cabbage, and at the same time, with the right hand, pulled the head a little over, so as to expose the roots. About half a teacupful of the liquid was then syringed forcibly around the roots, and the earth was quickly pushed up again around the stem. The result of this treatment was that only about one per cent. of the cabbages was lost. There is no doubt that the forcible syringing of the liquid removed the maggots to some distance from the roots; but by actual experiment it was found that the white hellebore killed them also." He records a further test of the decoction later in the season which resulted very satisfactorily, and from which it appeared that the hellebore killed by contact. He further says: "In applying this hellebore remedy care must be taken not to dig down too deep or disturb the root too much. The chief seat of

injury is the underground portion of the stem above the mass of roots. If about two inches of the soil be removed that part of the stem most attacked is laid bare, but the roots need not be disturbed. An important thing is not to put off the treatment too long." In 1892, and in 1893, he reports this hellebore tea in a large measure successful, but concludes that it is practicable only in gardens and not for field practice.

Although others have since recommended this hellebore tea, yet no one except Prof. J. B. Smith seems to have tested it. In 1892, Prof. Smith had one of his correspondents test it on the cabbage maggots, using on each plant one-half pint of the tea, containing one ounce of hellebore in one gallon of water; it was reported a success. However, he says: "As against the Onion Maggot, I scarcely know whether to recommend it as yet, without further experiment."

May 25, we put 100 small maggots about the base of a well-established cabbage plant. The next day when the maggots had begun work on the root, we poured 4 ounces of hellebore tea (1 ounce steeped in 1 gallon of water) in a cavity about the plant. Four days later, we found live maggots working on the stem near the surface; and June 7, 68 live puparia (and one maggot still feeding on the stem) were found in the cage. As only 71 puparia were found in a similar cage not treated, it was evident that our application had had but little effect on the maggots. In another similar cage the decoction had no effect on mature maggots and recently formed puparia. The hellebore used was practically fresh, as it had been kept in air-tight jars.

In the face of such positive results attained by so careful an investigator as Mr. Fletcher, it would not be fair to conclude from our slight experience that this hellebore tea is not an effective killing agent when used against these root maggots. And yet our experiment shows that there is need of further experimentation with the substance before it can be confidently recommended for indiscriminate use by gardeners. This simple remedial measure should be thoroughly tested by other investigators.

Kerosene Emulsion.

The first experiments we find recorded with a kerosene emulsion were made by Prof. Cook in 1884. He dissolved 1 qt. soft soap in 1 gal. hot water and then added 1 pint of kerosene oil. It was reported "a safe and very efficient specific against these very destructive maggots." He devised an instrument for applying it below the surface of the soil (Figured in Rept. Mich. Hort. Soc. for 1884, p. 204). Two years later, Prof. Cook treated radishes with a similar, but stronger, emulsion (1 lb. soap, 1 gal. water, 2 qts. kerosene) diluted with about 2 parts of water. Treatment was begun when the plants were small and continued every three or four days for 4 weeks; a tablespoonful was applied to each plant each time, and three-fourths of the plants were entirely free from the maggots. He concluded from his experiments thus far that, when made by the first formula, the emulsion was sure death to the maggots but must be applied early and often; he then preferred

it to carbon bisulphide for he found it just as effective and in no danger of injuring the plants.

In 1884, however, Mr. Goff experimented with an emulsion made of 4 lbs. of soap, 1 gal. kerosene, and 1 gal. water. One ounce of this was dissolved in one pint of water and repeatedly applied to the roots of an infested cabbage plant, with apparently no effect on the maggots. The amount of kerosene used by Mr. Goff was greater than that used by Prof. Cook at each application.

In 1887, Prof. Cook applied his emulsion freely 3 times a week to cabbages and radishes; it seemed to have no effect on the insect, but in one case it injured the plants. He concludes: "that I have killed these maggots both in the garden and on potted plants in the laboratory, by the use of the kerosene and soap mixture. Yet upon a thorough trial I am persuaded that the remedy cannot be made practicable." Mr. H. A. March of Washington State wrote the same year that Cook's emulsion cost him 2000 cauliflower plants. In 1889, Mr. Hulst carried on some experiments with the Riley-Hubbard emulsion which indicated that when diluted with 9 parts of water it injured the plants, but could be safely used when diluted with 12 or 15 parts of water and it would then also destroy the maggots. There would be about as much kerosene in a pint of this dilution as Mr. Goff had used in his experiment. In 1889, Dr. Riley advised Zimmer Broa. of Alabama to try the emulsion on their cabbages then infested by the maggots. They reported that when diluted with 9 parts of water, it killed every plant; but when 12 parts of water were used in diluting, no harm resulted to the plants and the maggots were destroyed. In 1890, one of Prof. J. B. Smith's correspondents reported good results from the use of the emulsion diluted 15 times. Mr. Fletcher found the emulsion successful in 1892 and 1893; but says it is not practicable for field use. The Riley-Hubbard formula* for the emulsion has been used since 1888.

The evidence so far is quite conflicting. Evidently the emulsion is the most effective when made by the Riley-Hubbard formula; but unless each gallon is diluted with at least 12 gallons of water, the plants are injured.

May 23, we placed 100 small maggots on the base of a well established cabbage plant. The next day, after they had begun feeding on the root, 4 oz. of the emulsion diluted with 9 parts of water was poured in a cavity about the plant; and a similar amount of a 1 to 12 part dilution was similarly ap-

*To make the Emulsion, thoroughly dissolve one-half pound hard or soft soap in one gallon boiling water. While this solution is still very hot add two gallons of kerosene and quickly begin to agitate the whole mass through a syringe or force-pump, drawing the liquid into the pump and forcing it back into the dish. Continue this for five minutes or until the whole mass assumes a creamy color and consistency which will adhere to the sides of the vessel, and not glide off like oil. It may now be readily diluted with cold rain water, or the whole mass may be allowed to cool when it has a semi-solid form, not unlike lopped milk. This standard emulsion if covered and placed in a cool dark place will keep for a long time. In making a dilution from this cold emulsion, it is necessary to dissolve the amount required in three or four parts of boiling water, after which cold rain water may be added in the required quantities.

plied to another plant on which 100 small maggots had been placed. The next day a superficial examination showed that many of the maggots were dying. June 8, 32 live puparia were found in the cage where the 1 to 9 part dilution had been used; and 40 puparia in the other cage. As from 71 to 95 puparia were found in similar cages receiving no treatment, it is evident that the emulsion killed many of the maggots.

The evidence would seem to support the conclusion that the kerosene emulsion (using 2 gallons kerosene, 1 gallon water, and one-half pound soap) diluted with 12 parts of water, will prove quite effective if applied early and often to radishes and onions, and two or three times on cabbages and cauliflower. It must be applied thoroughly, by first removing some of the earth from around the base of the plant and either syringing in the liquid or applying through a knapsack sprayer. It will prove practicable on a small scale, at least. We believe, however, that the carbolic acid emulsion or the carbon bisulphide treatment previously discussed, will prove more effective and practicable.

2. DESTRUCTION OF THE PUPAE.

(a) *By Destroying old "Stumps" in the Fall.*

Some authors have recommended the removal and destruction of the old "stumps" usually left in the field in the fall, in order that the puparia which they may contain be thus destroyed. We doubt if there are ever many puparia in these old "stumps" in the fall, but some maggots may thus be destroyed. Doubtless more of the insects would be destroyed by the destruction of the "stumps" of the early crop as soon as the crop is gathered. In any case the old "stumps" should always be removed, for although they may not contain many specimens of this pest, they furnish breeding places and shelter for other noxious insects.

(b) *By Fall Plowing.*

Künstler, in 1871, suggested that many of the hibernating puparia might be destroyed by plowing the ground late in the fall. Messrs. Riley, Lintner and Fletcher have also recommended it. Doubtless a late plowing followed by a thorough harrowing would destroy or deeply bury some of the puparia and thus help to check the pest.

(c) *By Use of Gas Lime.*

Dr. Lintner, in 1885, suggested that a heavy dressing of gas lime applied in the fall, would doubtless kill many of the hibernating puparia. It might,

3. INEFFECTIVE, OR IMPRACTICABLE METHODS.

Under this heading are grouped those methods which have been thoroughly tested and found ineffective or impracticable; and some methods are also included which have not been sufficiently

tested, but which we are inclined to believe will not prove effective or practicable. However, there are several methods in this latter group that should receive further investigation as is indicated in the conclusions drawn from the evidence submitted in the discussion of each.

A. PREVENTIVE.

I. BY ORDINARY FARM METHODS.

(a) *Selection of Soil.*

In 1886, the *Rural New-Yorker*, advised a correspondent to select a very sandy soil for a radish bed, to avoid injury from the maggot. The next year, in the same periodical, Mr. Goff gave similar advice. Yet Dr. Lintner said in 1882 that "the insect has been observed to be very injurious to earlier crops and upon *sandy* soil. It is thought that benefit has been derived from late sowing in *clayey* soil." We see no reason why the sandy soil would prevent or discourage the pest in any way. The soil in many parts of Long Island where the maggots work freely is quite sandy. The efficacy of the method is thus doubtful.

(b) *Time of Planting.*

Our discussion of the number of broods of this pest indicates that in some localities the first brood is not numerous enough to be noticeably destructive, while the second brood is often very destructive. This seems especially true in Canada. Hence, we find Mr. Fletcher and Mr. Fyles advising Canadian gardeners to sow radishes early, in May; but the former writer adds that this will not always prevent.

Farther south, in our State, all gardeners are aware that the pest is usually the most destructive to early crops. Hence, we find Cook in 1874, and Lintner in 1882, advising late sowing of radishes. In New York State, the pest rarely does much damage after July 1, so that gardeners find that late cabbages set at about this time escape with little injury from the maggots. In Canada also, Mr. Fletcher finds that cabbages set about July 15 are not troubled by the maggots. The application of the method then seems to depend upon the locality, as far as early crops are concerned, while late crops suffer but little in any locality. However, in many localities and especially on Long Island, it is the early crops that pay the best and are therefore the more largely grown; so that the time of planting is necessarily early, and the pest must thus be fought by other methods.

(c) *Trap Crops.*

In 1888, Prof. Cook concluded that the Cabbage Root Maggot relished radishes better than cabbages, and he therefore suggested that the latter might be preserved from attack by alternate rows of radishes. This, of course,

implied that the radishes were to serve as a trap crop to entice the flies away from the cabbages, and later the radishes were to be destroyed with their accompanying maggots. Others, notably Mr. Hulst in 1888 and Mr. Fletcher in a recent letter to the writer, say that the pest is especially fond of cauliflowers, attacking them in preference to radishes or cabbages. No careful experiments have been recorded in this line. Cabbages or cauliflowers could not be profitably grown as trap crops. Radishes might in some cases, but the evidence is not conclusive that the pest would attack this crop in preference to either of the others.*

Therefore, in the light of our present knowledge of the preferences of this pest, gardeners cannot expect to save a crop of cabbages or cauliflowers by growing radishes between the rows. Thus, while this suggestion of the use of trap crops to combat this pest promises but little of practical value at present, it should receive further investigation, for it would be interesting, to know at least the preferences of the insect, if it has any.

(d) Substances Applied to the Soil.

Under this head come those substances which gardeners use, primarily to increase the fertility of the soil, but which some have thought also acted as preventives of the attacks of the maggot.

Lime.

This substance has doubtless been used to prevent the attacks of this pest for half a century. Almost everyone who has written of the insect during the past 40 years, has recommended lime as a preventive. And yet, the first reference we have found of its use (a Maryland correspondent to the "Country Gentleman" for 1857, p.47) gives negative results. In many accounts of the use of the substance, it is not clear whether it prevents the "Club-root" or its supposed cause, the maggot; thus this evidence is not of much value. This is especially true of the many accounts of its use by Peter Henderson. In fact, we have failed to find a single recommendation to use lime as a preventive of the Cabbage Fly, which is based on careful experiments from which definite conclusions could be drawn.

On the contrary, there are some quite definite accounts which show negative results from its use. Mr. West ("Country Gentleman" for 1880, p.470) applied, early in the spring, lime at the rate of 15 tons per acre to a small bed; this was dug in after a few weeks, and good cabbage plants then set. In spite of this he lost $\frac{1}{2}$ of his crop from the maggots. Equally conclusive results were obtained in 1887 by Mr. Goff at Geneva, N. Y. He mixed "a quantity of air-slacked lime with the soil of two rows of a small plant of early cabbages at the time of setting the plants. As the season for

*Prof. Cook and others have recommended that if radishes were grown between rows of onions, the latter would be practically safe from the maggot. They probably would be safe from the Cabbage Root Maggot, but would they from the Onion Maggot? As we have shown on preceding pages, these insects are distinct species, and it is doubtful if the latter ever attacks radishes or the former, onions.

the attack arrived it appeared that the plants of the plot were all suffering, and an examination made June 18, showed that twelve plants treated with the lime had sixty-six maggots, while eleven plants not treated had but twenty-four maggots, proving conclusively the ineffectiveness of the application."

It thus seems to us from a critical survey of all the evidence we can find, that gardeners can not expect to *prevent* the attacks of the Cabbage Fly by the use of lime; its use as a destructive agent is discussed further on.

Salt.

Mr. Will (*Country Gentleman* for 1879, p. 167) and Mr. Hewes (*ibid.* for 1880, p. 39) claim to have had good results from the use of salt applied, in the hole in which the plant is to be set or on the surface around the newly set plant, to prevent the Cabbage Fly. Mr. West (*ibid.* for 1880, p. 470) used salt at the rate of three bushels per acre on a small bed at the time of setting the plants; he lost one-third of his crop. Doubtless the salt, thus applied, if it had any effect, would act by destroying the young maggots. Its destructive power is discussed farther on.

Salt and Lime.—A recommendation to mix salt and lime with the soil previous to sowing the seed or apply it to the surface after sowing, has found its way into the literature of root maggots. In 1843, Curtis quoted such a recommendation by a Mr. Sinclair, but it was to prevent the attacks of the Turnip Root Gall Weevil mentioned on a preceding page. As the separate use of these substances has not been attended with very favorable results as preventives, their combination would doubtless be no more effective.

Barn Manures.

So far as we know, stable manure has never been recommended as a preventive of this pest, but as it is one of the substances frequently applied to the soil by farmers, and as it doubtless affects the insect in a certain way, it seems best to discuss it in this connection.

When Bouché described the Cabbage Fly in 1833, he said that the avoiding of the use of new dung was of no avail; and this statement has been emphasized by almost every writer since. In fact, many prominent writers, including Curtis, Miss Ormerod, Lintner, Fletcher, and Henderson, all conclude that fresh manure attracts the flies and thus encourages, rather than prevents the attacks of the pest. This idea is well supported by several experiments recorded by gardeners. Thus, the use of fresh barn manures are to be avoided on crops attacked by root maggots; even where well-rotted manure is used the maggots seem to be more numerous. This is doubtless one reason why the commercial fertilizers are now largely used by gardeners. The probable reasons why the barn manures attract the pest are discussed on a preceding page under the food-plants of the insect.

Commercial Fertilizers.

Ashes.—In 1857, unleached ashes were used in Maryland without success (*Country Gentleman*, p. 319). Mr. Goff reported in 1885 that two years be-

fore in the spring, he forked in a very liberal dressing of coal ashes before sowing radish seed. "The roots produced were nearly or quite as badly infested with the maggot as others grown without an application of ashes." Thus there is no evidence that ashes will prevent injury from maggots.

Bone Dust.—This substance has been recommended by various writers since Henderson recorded ("Gardening for Profit") an experiment which simply indicated that fewer plants were injured where a ton of this was used per acre in the spring, than where 75 tons of manure were applied. However, in 1864, a German experimenter found that his bed of Kohlrabi which had been manured with bone dust suffered more from the maggot's than the one on which horse dung had been used.* In 1875 (*Country Gentleman*, p. 505) Mr. Philbrick said bone dust does not give the results given by Henderson. Mr. West (*Country Gentleman* for 1880, p. 470) also used it at the rate of a ton per acre, and yet lost one-third of his crop of cabbages. Thus the weight of evidence is against the efficacy of bone dust as a preventive.

Cotton Seed Meal.—In 1887 (*Rural New Yorker*, p. 133), Mr. Henderson records an experiment by Mr. Geraty of South Carolina who claimed to have secured entire exemption from the maggots by the use of this substance as a fertilizer. We have found no further reference to it. It might be well to test it in localities where it can be profitably used as a fertilizer.

Superphosphate of Lime.—In 1857, this fertilizer was reported as a successful preventive of the Cabbage Root Maggot (*"Country Gentleman"* p. 49). In 1864 the substance was used in the noted German experiment mentioned above in the discussion of Bone Dust; in the bed manured with this fertilizer, no plants were attacked. This experiment is the source of most of the recommendations of this fertilizer. In 1877, Garfield of Michigan reported that he treated alternate rows of turnips and radishes with it, hoping that its vile smell would prevent egg-laying; it proved a failure. If it has any preventive qualities, which we doubt, it should receive the immediate attention of some investigator.

(e) *Change of Location, or Rotation of Crops.*

Many writers have advised that the location of the crop be changed every year or two, thus keeping it out of the way of the insect. But, as Prof. Cook says, it would be necessary to move it at least $\frac{1}{2}$ a mile away, which is not often practicable. When it can be done, doubtless good results will often

* This experiment is referred to by Dr. Lintner and Miss Ormerod as having been made by the Zoölog-Botan. Society of Vienna, which, if true, would give it great weight. But the facts are that it was simply recorded in the proceedings of that society for 1864 by Mr. Künstler to whom it was reported by Baron Hohenbruck. The experiment was evidently on a small scale, and Mr. Künstler concludes as follows: "It does not occur to me to wish to deduce, from this single result, the value of any of the named manures in view of an eventual efficiency against the attacks of the insects; I present this case only to urge the farmers to make observations in this direction with manure experiments. . . . An effective and practicably applicable means of lessening this pest, no one as yet knows." The species experimented upon was determined by Frauenfeld and Schiner, from the pupae, as *Anthomyia radicum*.

follow. However, some gardeners have found that even when the crop is grown on new ground, where perhaps a similar crop has never been grown, that the crop is sometimes badly infested. In this case, perhaps some of the flies from an old bed found their way to the new, but the more probable explanation, we believe, is to be found in our discovery that the pest breeds freely on at least two very common Cruciferous weeds, which would thus afford a source of infection. So that a sufficient change in the location of the crop is not often practicable, and will often prove unsuccessful if Cruciferous weeds abound in the new field.

A judicious rotation of crops can not help but discourage this pest, and thus gardeners may be able to grow a good crop of one or more of its food-plants once in perhaps two or three years. But the market wants these crops every year, and it will thus require considerable experience to know what crops can be thus successfully rotated and all be made to pay well. Of course, the rotating crops must be widely different botanically so as not to offer any chance for the insect to continue breeding in the locality, and no Cruciferous weeds must be allowed to grow in the neighborhood, for the insect could breed on these until its favorite food-crop came around in the rotation. On the whole, therefore, while both a sufficient change of location of the crop and a judicious system of rotation of different crops each year will prove quite effective in preventing the ravages of the pest, we fear that few gardeners will find either method practicable or uniformly successful.

2. BY APPLICATIONS TO THE ROOTS BEFORE SETTING.

This is one of the earliest methods employed in combating these maggots, and is only applicable to plants of the cabbage tribe. It consists in dipping the roots and base of the young plants in a puddle of some fertilizing or insecticidal substance when the plant is being set.

(a) *Fertilizing Substances.*

Puddle of Earth and Cow Dung, or Night Soil.

In her report for 1881, Miss Ormerod said: "Dipping the plants in a puddle of earth, and cow-dung, or night soil, taking care to smear the roots and stems well up to the leaves with the mixture, is noted as a good preventive." This has been quoted by several American writers. This puddle would seem to offer no obstacles to the flies, in fact, it would attract them, if anything, and if the pest was at all numerous it would not save the plant. For its only effect would be to furnish the plant quickly available food at the start which would push it along, and in this way enough roots might be produced to support several maggots and the plant also. The method would require considerable disagreeable labor, and we believe would have no effect in lessening the number of the maggots.

Soot, and Lime and Soot.

In 1883, one of Miss Ormerod's correspondents found that the dipping of the roots in a thick puddle of soot and water was quite effective. He thought

the soot gave the plant a bitterness which warded off the maggots. Gardeners could easily try it on a few plants, but we doubt its having any preventive value.

Lime and Soot.—We find a puddle of lime and soot advised in Miss Ormerod's "Manual of Injurious Insects," and by "Horticola" in the "Rural New Yorker" for 1831. There are no definite records of its value. The lime would have little or no preventive effect, and there is but little evidence in favor of the soot as shown above.

(b) *Insecticides.*

Oil or Lye.

Several American writers, including Lintner, Riley, Saunders, and Fyles, have included in their remedies for this pest the recommendation to dip the roots in either oil or lye before setting. This seemed to us a very harsh treatment for the tender rootlets of seedlings, and we were thus led to wonder how the recommendation crept into the literature to be handed down to the present time. The two first named authors attributed it to Bouché. Turning to Bouché's earlier accounts in 1833, we find, following London's literal translation of Kollar in 1840: "Dipping the plants to be transplanted in oil or lye of ashes, or soaking the holes that are to receive them with these liquids, will often destroy the plants, and cannot therefore be recommended." How could a positive recommendation be evolved from that? A search through the literature soon revealed who evolved it. Turning to Curtis' account of the insect in 1843, we find this: "It often happens that very good specifics which may be successfully employed in the garden cannot conveniently be extended to the field; such, I fear, is the following remedy proposed by Bouché. He says that where whole fields of cabbages have fallen a sacrifice to the destructive maggots, that the crops are now completely preserved by dipping the roots, as they are transplanted, into oil or lye of ashes." It is unfortunate that our American writers have depended so much on Curtis' account of this pest, both from a systematic and economic standpoint.

Pyrethrum.

In this report for 1885, Mr. Fletcher says: "In my own experience the most satisfactory preventive treatment has been to dip each plant bodily into a pail of pyrethrum wash (containing a little soap) at the time of planting out." In addition to this he uses fresh gas lime around each plant to prevent eggs from being laid. It is doubtful if the pyrethrum has any preventive effect used in this manner; whatever protection is offered, is doubtless due more to the gas lime.

Paris Green and Insect Powder.

In 1886, a Massachusetts correspondent ("Rural New Yorker," p. 840) tried to save his cabbage and cauliflower plants by dipping them before setting in a puddle of dirt and water to which a quantity of insect powder

(pyrethrum?) and Paris Green was added. The plants soon dwindled and died from the treatment.

Sulphur.

A Washington State correspondent, Mr. H. A. March ("Rural New Yorker," p.678) in 1889 records an experiment in which he saved many plants by dipping them in a puddle of $\frac{1}{2}$ pound of sulphur and water. However, no definite conclusions can be drawn from the puddling, for matters were complicated by the further application of $\frac{1}{2}$ teaspoonful of dry sulphur on the soil around each plant after setting. The evidence warrants a further trial of sulphur either as a puddle, or applied on the surface.

Soap and Quassia, or Carbolic Acid and Soap.

Mr. Whitehead, of England, in his report for 1892 advises that plants be dipped in "solutions of soft soap and quassia, composed of 7 lbs soap, 12 lbs. of quassia, to 100 gals. of water; or of 7 lbs. of soft soap and 6 or 7 qts. of carbolic acid." No evidence is given in support of either recommendation and the effectiveness of the first is very doubtful, while the second would be liable to injure the plants.

3. APPLICATION ON OR ABOUT THE PLANTS.

(a) Coal Dust, or Sulphur.

Coal Dust.—All the recommendations of this substance as a preventive are based on an experiment made in Russia in 1855 (Bull. d. l. soc. imp. des natural, de Moscou., XXVIII). Through Taschenberg's account of this experiment, it has clung to the literature to the present time. The experiment indicated that the flies avoided those plants about which coal dust has been scattered. But, as Taschenberg observes, it is necessary to the success of the experiment, that some plants be left untreated as baits to entice the flies to oviposit on them; these baits are afterward to be destroyed with their accompanying maggots. When no plants are left for baits, Taschenberg says the flies then accommodate themselves to the beds entirely covered with the coal dust. It is curious that so simple a preventive seems not to have been tried since this first experiment. We have but little faith in its effectiveness, but it should receive a trial wherever practicable.

Sulphur.—All the evidence in regard to the use of this substance as a preventive seems to come from Mr. H. A. March, of Washington State. His method of using the substance has been stated above in discussing the puddling of the roots in sulphur. Mr. Crozier ("The Cauliflower," p.98) quotes Mr. March as follows: "The best thing I have found for the maggot is a *poor* grade of sulphur, sulphur before being purified, that *smells very strong*. Sprinkled over the plants it seems to drive the fly away." The substance is evidently worthy of a further trial.

(b) Insecticides.

Powdered Tobacco, and Tobacco Decoction.

In 1857 ("Country Gentleman," p. 319) E. Saunders reported that an Albany

In planning the preventive experiments to be tried on our plot on Long Island this year, it was decided to test tobacco dust; for it has the merits of cheapness (costing from 1 to 3 cents per pound), it is easily applied, has fertilizing qualities, and its use would thus be practicable. On April 18 the cabbages were set in six rows, running east and west, of about 300 plants each. The plot was divided into practically equal parts by a north and south division line. The following diagram represents the plan of the preventive experiments; the treated rows being represented by the name of the preventive used on each, and the word "untreated" represents the other rows:

WEST.	1st row :	Tobacco Dust	Paper Pads	EAST.
	2nd row :	untreated	untreated	
	3rd row :	Paper Pads	Carbolic Acid Emulsion	
	4th row :	untreated	untreated	
	5th row :	Carbolic Acid Emulsion	Paper Pads	
	6th row :	Paper Pads	Tobacco Dust	

April 19, the day after the plants were set, we applied the dust. All the dust that could be grasped in one hand sufficed for three plants, thoroughly dusting each plant and covering the ground close to the stem; at this rate, 7 lbs. of the dust treated about 300 plants once. April 30, a second similar application was made by Mr. Reeve at our request. At that time he reported that the plants were all looking healthy and showed no differences; he noted a good many flies about the plants. May 15, we had Mr. Reeve treat the west half of the first row with the dust a third time, to thus test the effect of two and three treatments. May 21, we examined the plot and found that chickens had destroyed about 25 plants on the west end of each row; however, this interfered but little with the general results of the preventive treatments which were then quite noticeable. The maggots were then at their worst, and there were scarcely 50 plants in either of the untreated rows that had not wilted. While about $\frac{1}{2}$ of those treated with tobacco dust had

succumbed, with no difference noticeable in those treated two and those treated three times. In August, Mr. Reeve reported that 35 heads were cut from the west half of the first row and 75 heads from the east half of the sixth row. Thus nearly half of the plants treated with the dust produced salable heads; while from the untreated rows Mr. Reeve reported only 90 heads from nearly 600 plants set.

Plants can be treated once with this tobacco dust at a cost of not over one cent for ten plants, and the experiment indicates that it affords some protection, but there were other untreated plants to act as baits. And an examination May 21 of many of the treated plants that were apparently healthy, showed that several maggots were at work on many of them. Therefore, we are not sufficiently convinced of its effectiveness to feel warranted in advising its general use as a preventive against the maggots.

Carbolic Acid, diluted, emulsified, or combined with Plaster.

Carbolic Acid, diluted.—In 1886, Mr. Goff reported the following results with this substance: "On May 2, we applied this solution at the rate of 3 grammes of the acid, to 5 gallons of water, to the soil about the roots of a row of radishes in the garden. On May 11, we renewed the application, doubling the amount of the acid. May 18, we repeated it, using 8 grammes of the acid to 5 gallons of water, following with the last named solution on May 23. No benefit resulted from these applications that we were able to detect. It is possible that the plants would have borne a still stronger solution, which might have been efficacious." We believe it would have been effective if used stronger, but it is our experience that it is just as effective, perhaps more so, and not so liable to injure the plants if applied in the form of an emulsion.

Carbolic Acid Emulsion.—This preventive was first suggested by Prof. Cook in 1881. He then made an emulsion by dissolving 2 qts. of soft soap in 2 ga's. of water, and then adding 1 pint of *crude* carbolic acid, thoroughly agitating the mixture which soon formed a stable emulsion. To every pint of this standard emulsion he used 50 pints of water to dilute it before applying; thus the acid was used on the plants at the rate of a pint to about 125 gals. of water. He got excellent results by sprinkling the radish plants as soon as they were up, and thereafter every week or ten days. In 1886, Prof. Cook again experimented with this emulsion, but made it with 1 lb. soap, 1 gal. water, and $\frac{1}{4}$ gal. crude carbolic acid; diluted with 75 parts of water. The acid was thus used at the rate of about 1 pint to 28 gallons of water, or over 4 times as strong as he used it in 1881. This was applied to cabbages, a tablespoonful to each plant, at intervals of from 4 to 7 days for 3 weeks, with the result that only 5 out of 21 treated plants were injured by the maggots, while 16 out of 24 untreated ones were attacked; the plants were uninjured. He also used the same strength of emulsion on radishes, a teaspoonful to each plant, with the result that 5 out of 18 treated plants were found infested, while 22 out of 32 untreated ones were badly injured; all of the plants, however, were injured by the liquid. Prof. Cook seems not to have tried the

emulsion again. Had he made it according to his first formula and used it more freely, we believe he would have had greater success in 1886.

For, this is the experience of others who have tried the emulsion. During the summer of 1887, Mr. Fletcher used Prof. Cook's first formula, diluting it 50 times, on radishes. He began 2 days after the seed was sown and treated the bed, using an ordinary sprinkler, once a week until the radishes were fit for the table. He grew radishes in this way all summer free from attack, with no injury to the tenderest foliage nor was any offensive taste given to the vegetable.

This emulsion was selected as one of the preventives to be used on the cabbages in our experiment on Long Island. Our emulsion was made by dissolving 1 lb. of soap in $\frac{1}{2}$ gal. of water and emulsifying this with 1 pint of crude carbolic acid. Each cupful of this was diluted with 50 cupfuls of water before applying; thus about 38 gallons of the dilution would contain 1 pint of the acid, or the emulsion was used about 3 times as strong as Prof. Cook first used it. Our experiment was planned as described in the diagram on page 551. Two half rows were treated with the emulsion, or about 300 plants in all. About $\frac{1}{2}$ teacupful of the dilution was poured in a solid stream from an ordinary sprinkler around the base of each plant. The first application was made April 19, the day after the plants were set. A second application was made by Mr. Reeve on April 30. On May 21, when we examined the plants, the maggots had done their worst, and in the untreated rows there were scarcely 50 plants yet standing in either row. While about $\frac{1}{4}$ of those treated with the emulsion were in good condition and but few of them had any maggots at the roots. In August, Mr. Reeve reported that he had cut 90 heads from the west half of the fifth row and 85 heads from the east half of the third row; while from the untreated rows he got only 90 heads from the 600 plants set. Thus the results were quite encouraging.

However, we doubt if the emulsion applied early in the season, acts to prevent the flies from laying their eggs. Our experiments, recorded on page 529, indicate that it is a powerful killing agent, and there is yet no definite evidence that smells of any kind will keep the flies away. The discussion of the emulsion as a killing agent on page 529 should be read in connection with this account.

Carbolic Acid and Plaster.—In 1888, Prof. Cook mixed the *crude acid* with plaster (1 pint to 100 pounds of plaster), and applied it around the stem of cabbage plants. "None of the cabbages were attacked, but the slaking or setting of the plaster about the plants was a serious injury to some of the plants." Therefore, he could not advise its use for this purpose.

B. DESTRUCTIVE.

I. DESTRUCTION OF THE MAGGOTS.

(a) *By Destroying Infested Plants.*

In 1833, Bouché concluded that the only way to diminish this destructive fly is to pull up and destroy the infected plants with their accompanying

maggots. Many later writers have included this method among their remedies for the pest. Of course, there can be no question of its effectiveness in checking the insect, but every plant thus destroyed represents considerable labor to the gardener, besides the reduction it makes in the profits when the crop matures. We believe there is no occasion for the practice of the method. The maggots may be killed in several ways, as has been shown, without injury to the plant.

(b) *By the Application of Direct or Indirect Fertilizers.*

Ammonial Liquor.

This refuse liquor from gas works was used by one of Miss Ormerod's correspondents in England in 1881. It was diluted with about twice the quantity of water, and one pint of the dilution was applied around the stems of each plant. Three or four such doses saved only the plants that were not too far gone when the treatment was first applied. We doubt if the liquor would kill the maggots; it would probably simply encourage or stimulate the plants to send out enough roots to support itself and the maggots also.

Soot.

Last year, at the Pennsylvania Experiment Station, soot was sprinkled about some cabbages which were found infected by the maggots. It seemed to save a few plants. No definite opinion can be formed from this single experiment. Wherever soot is plentiful, its destructive powers should be further tested.

Ashes.

In 1861, Mr. Gregory advised that ashes be used around the plants to destroy the maggots. Mr. G. H. Howard, in 1888, said that a small handful of wood ashes put down around each stem is a sure remedy if applied in time, that is, before the maggots have destroyed the bark and roots of the plants. However, Prof. Cook, in 1886, used unleached ashes against the maggots with no success. When sprinkled on the foliage the plants were seriously injured. Last year, Washburn in Oregon, had fairly good results, but the ashes had to be applied frequently. Possibly enough ashes could be applied to the maggots to kill them, but the amount that could be safely applied to the plants doubtless acts simply as a fertilizer thus enabling the plant to make roots enough for itself and the maggots. Mr. Howard evidently implied this when he stipulates that the bark and roots must be intact or the ashes are not effective. Thus, we do not believe ashes can be relied upon to destroy the maggots.

Nitrate of Soda.

In 1881, a correspondent reported to Miss Ormerod that an application of a solution of this substance saved only a few plants. Mr. Fletcher reported in 1887 an experiment by one of his correspondents which indicated that the substance might act remedially. In 1891, Prof. J. B. Smith recorded his

belief that this fertilizer would do much to control the injury from the maggots, but it should never be applied close to the plants, but broadcasted.

Thus there is no experimental evidence from which can be drawn definite conclusions in regard to the action of this fertilizer on the maggots. However, as Mr. Whitehead said in 1892, it has been found valuable, for if it fails to act remedially, it at least stimulates the plant's growth and thus helps it along out of the way of the maggots. As a killing agent against the maggots, we believe it has no value unless used so strong as to kill the plant also.

Muriate or Sulphate of Potash.

In 1887, the editor of "The Rural New Yorker" suggested that Mr. Henderson try the muriate on the maggots. In 1889, Mr. G. H. Howard advised that to each plant be applied a gill of a solution made by putting one spoonful of the muriate in a quart of water. However, he made the same proviso as to its effectiveness as mentioned above in discussing ashes. In a pamphlet on the "Cauliflower," Mr. Brill says (as quoted from Crozier on "The Cauliflower") that the muriate is a remedy for the maggots. He dissolved 1 tablespoonful in a gallon of water and applied one gill of this to the roots of each plant, repeating the application as occasion required. He well says: "Care and judgment must be used not to overdo the matter, thereby killing the plant as well as the maggots. Experiment a little at first." Mr. Brill wrote us in August as follows: "While my experiments with the Muriate of Potash to kill the root maggot was in the first instance a success, yet it does not always have the desired effect. I presume much depends upon the conditions of the worms and the plant when applied." Thus there is nothing definite in the evidence either for or against the effectiveness of the muriate on the maggots. We have no faith in the killing or preventive properties of either the muriate or the sulphate of potash unless used so strong as to injure the plant also.

Kainit.

This fertilizer was first used against the root maggots at least 7 or 8 years ago. One of its first advocates was Mr. Brill; his pamphlet on the "Cauliflower" is doubtless the source of the few recommendations which the substance received until within about 4 years. In 1890, Prof. J. B. Smith had his attention turned to kainit as a possible insecticide, and he performed the following experiment with it on the pest under discussion: "A number of cabbage maggots placed on the soil (in a tin can) impregnated with the solution, died within 12 hours." (These were very unnatural conditions.) No further experiments seem to have since been carried on with this substance against the Cabbage Root Maggot.

Last year Prof. Smith had some of his correspondents experiment with kainit on the Onion Maggot (An. Rept. for 1893. p. 441). He says: "The entire fields were gone over, row by row, and all plants that showed signs of infection were taken out bodily and afterwards destroyed. Then heavy dressings of kainit were applied, with the result that no further traces of

these maggots were seen at any time later in the season." This year he reports similar results from a similar use of kainit in the same locality (*Insect Life*, vii, 196). It is to be regretted that Prof. Smith could not have made these experiments more conclusive by his personal supervision. The destruction of all of the plants that showed any signs of infection *before* the kainit was applied, prevents very definite conclusions from being drawn as to the destructiveness of the kainit. In his report for 1893, p. 441, Prof. Smith mentions that some experiments were made on a fly larva which was at first mistaken for the Onion Maggot. He writes us that "this Orthalid larva was remarkably resistant to almost anything that I could use, except the kerosene"; recently (*Insect Life*, vi, p. 96) he intimated that kainit was one of the substances used on these maggots which were found in diseased onions and which are so closely allied to the Onion Maggot as to have been mistaken for it.

It is also worthy of note in this connection that in one of the first references we find to the use of kainit against this pest (*Rural New Yorker* for 1887, p. 238), a Georgian contributor says it must be put on in time to kill the eggs, for it will have no effect on the maggots after they hatch. From the above evidence, we do not feel warranted in recommending that gardeners may expect to kill the root maggots by an application of kainit that would not at the same time kill the plant.

We are supported in this opinion by the following experiments, conducted on maggots brought here from Long Island. Several thrifty cabbage plants were potted out, and on May 23 some of the soil was removed from around the base of the plants and 100 maggots, none of them over $\frac{3}{4}$ grown, were placed close to the base and covered with earth. They were left undisturbed until the next day when it was found they had established themselves on the plants. May 24, the soil was removed until at least 25 of the maggots were laid bare. Then 4 ounces of a solution of kainit ($\frac{1}{2}$ lb. to a gallon of water) was poured around the stem; in one case 20 of the maggots floated about in the solution for over a minute. Another similar cage with 100 small maggots was started May 25, and the same amount of kainit applied on the 26th. One of the cages was examined May 25, and the notes say: "No indications that even the smallest maggots have been killed." By June 6, when all of the cages were carefully examined, most of the maggots had changed to pupae. In the cage where the maggots were mentioned as floating in the kainit solution, 83 live pupae were found; in the other two treated cages there were 50 and 63 live pupae, respectively. An examination of two check cages started at the same time in a similar manner with 100 small maggots, but not treated with kainit, revealed 95 live pupae in one and 71 in the other. If the kainit used at the rate of $\frac{1}{2}$ lb. to 1 gallon of water is not more effective on the maggots under these somewhat confined conditions than these results show, one surely could not advise gardeners to use it with the expectation of killing the maggots.

To test a stronger solution, we started two similar cages of 100 small maggots on May 24. May 25, 4 ounces of a solution of the kainit (1 lb. to 1 gal.)

was poured into a cavity about the base of the plant as in the experiments above; in one cage nearly $\frac{1}{2}$ of the maggots were near the surface and thus got a thorough soaking. In 2 or 3 days a superficial examination showed that a few maggots had been killed, and many had not, but both plants were considerably injured by the solution. To further test the effect of this strong solution on the plant, it was applied to plants having no maggots on their roots. June 6 all of the cages were carefully examined. Sixty-four live pupae, many of them recently formed, were found in one and 50 in the other cage. The plants were all badly injured by the solution. The same check cages were used as in the preceding experiments.

We do not offer these experiments as conclusive evidence that kainit will not always kill the Cabbage Root Maggot. But the results do show that it will not always kill the majority of the maggots even when used strong enough to badly injure the plants. Thus, from the evidence submitted, we cannot escape the general conclusion that it would be well to first definitely settle, by careful experiments, whether kainit will kill a majority of the maggots when used in practicable amounts, before we recommend it to gardeners for this purpose.*

Salt.

The first record we find of the use of salt as a destructive agent against root maggots is in 1877, when Mr. Garfield of Michigan partially removed the soil from the roots of infested cabbages, then salt was thrown in and covered up; "it soon dissolved, but to no purpose." In 1881, Miss Ormerod reports that a solution of salt saved but a few plants. A solution of salt at the rate of 4 oz. to one gallon was tested by Mr. Goff in 1889; "it produced no visible effect." Mr. Fletcher recently reported conflicting results from its use against the maggots.

* Although we do thus doubt the insecticidal qualities of kainit when used against the root maggots in practicable quantities, we do not wish to discourage its use by gardeners for fertilizing purposes. And yet, as Mr. Wright Rives, of Washington, D. C., has so tersely expressed it in a recent letter to us, "I want potash, not salt; therefore I do not use kainit." In some cases these commercial fertilizers may furnish to the plants, just at the right time, the food needed to enable them to outgrow the injury caused by the insect. But, the insect still remains a constant menace to the gardener. Mr. Fletcher showed in 1890 that "the power of the cabbage plant to survive and outgrow injury is very remarkable. Several plants of which the roots and nearly all the underground stems had been destroyed, were washed and trimmed, and then planted and watered, and the earth kept well hoed up around them. Every one of these grew and produced a head. In years of only light attack it is not at all uncommon to find when cabbages are pulled up, that they had been supported by roots which were produced some distance above the root-mass, which had been destroyed early in the season by the cabbage maggot." There are several accounts of the use of commercial fertilizers on plants infested with the root maggots, but with no claim of having saved the crop by the maggots having been thus destroyed. As Peter Henderson expressed it when he used guano and lime: Strong roots were made above the wounds, and thus the crops were saved; it would have failed to be effective if the ravages of the maggots had been far advanced. We have discussed the insecticidal value of commercial fertilizers at some length in answer to several correspondents in the "Rural New Yorker" for March 24, 1894, p. 184. Prof. J. B. Smith stated his views on the same subject in a note in the same paper for April 28, 1894.

This spring we potted out a thrifty cabbage plant, and May 25, 100 small maggots were introduced around the base of the plant. The next day when the maggots had become established on the root, 4 oz. of a solution of salt (1 pound to one gallon of water) was poured in an excavation around the base of the plant. This treatment resulted in the death of most of the maggots and the plant also; it was thus more effectual than the kainit of the same strength. Thus all the evidence is against the use of salt to destroy the maggots, unless it is desirable to destroy the plants at the same time.

Dry Lime or Lime Water.

Lime in a dry condition has been extensively used as a preventive against the maggots, but the literature contains only a few references of its use as a killing agent. In her report for 1881, Miss Ormerod says caustic lime was not very effective as it could not easily reach the roots. In 1888, the "Rural New Yorker" reported that plants treated with air-slaked lime to kill the maggots suffered more than those untreated. Last year Butz and Baldwin in Pennsylvania, and Washburn in Oregon used the dry lime with partial success. It is thus very doubtful if the lime used dry will destroy any of the maggots.

Lime Water.—The source of nearly all the recommendations for the use of lime water to destroy the maggots is a report by Miss Ormerod in 1881 from one of her correspondents who soaked the lime 48 hours and then applied it with apparent good results. We doubt if lime in any form will either prevent or kill the maggots.

(c) *By the use of Insecticidal Substances.*

London Purple or Paris Green.

London Purple.—Prof. Cook experimented with this in 1887. Several applications were made about the roots of early cabbage, beginning soon after the plants were set and continuing until after the flies had stopped egg-laying. "At this time an examination of the plants showed them to be nearly as badly infested with maggots as were the untreated rows."

Paris Green.—In 1886, Prof. Cook reported that Paris Green was used at a strength of 1 pound to 40 gallons of water for the maggots. "It neither injured the plants nor the insects." In 1890, Mr. Fletcher treated a dozen plants with it (1 lb. to 100 gals.); its application noticeably checked the growth of the cabbage, and it failed to kill the maggots.

Pyrethrum.

In 1886 and 1887 Prof. Cook tested this substance thoroughly, both as a powder and as a decoction in water, but without any effect whatever.

Tobacco Water.

In the "Country Gentleman" for 1859, p. 27, we find the first recommendation of this tobacco decoction to kill the maggots; it had been tried as a preventive several years before. The first experiment we find recorded is by Prof. Cook in 1887. He faithfully used a strong decoction "about radish

plants for the destruction of the maggot, but all to no effect." This year Mr. Washburn has reported fairly good success from its use in Oregon. The evidence is not sufficient to recommend it as a destructive agent against the root maggots.

Kerosene.

In 1887, Mr. Goff used this substance on the maggots at work on cabbages. It proved fatal to both the plants and the insects.

Paraffin Oil.

This substance was mixed with water and used by some of Miss Ormerod's correspondents in England in 1881. It had but little, if any, effect on the maggots.

Soap Combinations.

Soap Suds.—In 1875, a correspondent to the "Country Gentleman" claimed to have killed the maggots by applying $\frac{1}{4}$ pint of a solution of 1 part soap to 12 parts of water; three applications were made during the season. In 1881, a correspondent reported to Miss Ormerod that drenching his cauliflower plants with strong soap suds had no effect on the ravages of the maggots. Prof. Cook, in 1887, also applied strong soap suds faithfully, 3 times per week on radishes and cabbages, with no apparent effect on the maggots.

Whale Oil Soap.—Prof. Cook also used this in his experiment in 1887, without success.

Whale Oil Soap and Sulphur.—This was recommended by Prof. Cook in 1883, but no one seemed to have tested it. It would doubtless be ineffective.

Soap Suds and Gas Water.—This was recommended by Mr. Major in 1829 in his "Treatise on Insects," but it was to be used to make the plants offensive to the Turnip Gall Weevil and not for the Cabbage Root Maggot, on which it would doubtless have but little effect.

Boiling Water.

As Dr. Walsh states (Prac. Ent., i, 20), this method seems to have been first used by a Dr. Drew (who published it in the "New York Tribune" several years previous to 1865) on the Onion Maggot. In 1870, Dr. Riley recommended it for the radish maggot. In 1874, Prof. Cook says: "I have tried this with some, though not satisfactory success." Mr. Garfield reported in 1877 that he "poured boiling water upon the roots, and when the maggots were not too deep in the ground this was effective, but on the whole was not considered a successful remedy." Doubtless very hot water would kill the maggots could they be hit by it; but the soil would soon reduce the temperature of the water below the killing point, so its use would not be practicable.

Saltpetre (Nitrate of Potash).

In 1885, Dr. Lintner suggested that this substance be tested on the root maggots. Two years later, at Dr. Lintner's request, Mr. Goff thoroughly tested it. His experiment is so conclusive that we quote it in full: "On the first indication that the cabbage plants were infested, which was on May 31

a solution of saltpetre, at the rate of 1 lb. to 2 gals. of water, was applied to alternate rows of a plat of cabbage plants. The application, which was repeated on June 4, 10, and 16, was made by pouring one or two gills of the solution around the stem of each plant, from a sprinkling pot, from which the rose was removed. On June 18, an examination was made of all the plants in 4 rows of the plat, 55 in number, with the following results: Twenty-nine treated plants were attacked by 124 maggots. Twenty-six not treated were attacked by 25 maggots. One of the treated rows was on the outside of the plat, and these outside rows and the ends of the inside rows were more infested than the others. The greater number of maggots found in the treated rows is to be ascribed to this fact, and not to an assumption that the nitrate of potash attracted the fly. The last application was made but 2 days before the examination, but many live larvæ, that had apparently just hatched, were found in the treated rows, thus showing that the solution was harmless to the insects. As an additional test, a cabbage plant badly infested with maggots was placed in a flower pot, and treated repeatedly with a saturated solution of the salt, but no effect upon the insects was observable." In 1888, the editor of "The Rural New Yorker," p. 149, also reported no success from the use of this substance against the maggots.

Corrosive Sublimate.

An editorial in 1864 ("Country Gentlemen, p. 65) states that a contemporary recommends 1 oz. of this substance dissolved in 4 gals. of water to destroy the root maggots. A correspondent to a Canadian journal ("American Cultivator" for April 37, 1881) says all of the London market gardeners secretly use a solution of $\frac{1}{4}$ oz. of this substance in 4 gals. of water for these maggots. He had used the solution quite extensively, using enough to saturate the ground. But it is not clear from the account whether it is applied as a preventive or whether it kills the maggots. We have but little faith in its effectiveness, but it should be further tested. Remember it is a virulent poison and great care must be used in handling it.

Epsom Salts (Sulphate of Magnesium.)

In 1881, one of Miss Ormerod's correspondents reported fair success in destroying the maggots with a solution of this well-known cathartic. It might be well to test it on a small scale.

Liver of Sulphur (Sulphide of Potassium.)

In 1887, a correspondent ("Rural New Yorker," pp. 431 and 626) reported in detail some experiments by which he claimed to have killed maggots on his cauliflowers by pouring a large teaspoonful of a solution on this substance (1 oz. to 3 qts. of water at 100 degrees) on the soil around the stalk; 24 hours later the maggots were apparently dead, but his account of the appearance of his "dead" maggots strongly impresses one that he saw only puparia or the empty shells from which the flies had emerged.

The next year, at Dr. Lintner's suggestion, Mr. Goff carefully tested the

substance as follows: "An ounce of it was dissolved in a gallon of water at a temperature of about 107°F., and when cold, 2 teaspoonfuls of the solution were poured about the stem of each plant. The first application was made May 5, which was before the plants had manifested any injury from the maggot. At this strength, the plants appeared to suffer somewhat, hence the latter applications, made May 21, and June 5, were reduced to $\frac{1}{4}$ of an ounce to the gallon, and about a gill of the liquid was poured about each plant. On June 6 examination showed that the plants were suffering from many live maggots, and there were no indications that the treatment had caused any diminution in the number." The substance has decided fungicidal properties, but the evidence thus far will not warrant its use by gardeners in fighting the root maggots.

Tansy, or Burdock Decoction.

Several years ago a contributor to the "New England Homestead" stated that the following decoction was a "dead shot for the maggot:" "Take green burdock leaves and stalks, run them through a hay-cutter, put them in a kettle or tub, and mash them with an old ax or mall, adding water and pounding them to a pulp. Let it stand over night. Have the decoction strong, and when you see the first signs of the maggot, use it. Apply it with a sprinkler by pouring it along the rows. I seldom have to apply it the second time." Dr. Lintner adds that "a strong decoction of tansy, where it is abundant, would probably be about as serviceable as the burdock." These recommendations seem to have received no further notice. We doubt if they can be depended on to destroy the maggots, but they should at least receive a thorough trial.

Mercury and Pulverized Earth.

The combination had been recommended in California for the Grape Phylloxera; and so Mr. Goff, in 1885, put a little of the mixture about cabbage plants infested with maggots. It "seemed to have a beneficial influence, but was not an entire success." Some dead maggots were found, but there were others alive, in immediate contact with the mixture.

McDougall's Sheep Dip.

In 1888, Mr. Goff diluted this substance with 5 parts of water and tested it on cabbage to kill the maggots. The insects were not injured but the plants were killed.

Zoektin Poison.

Mr. Goff tested this in 1888, using 1 oz. to 5 gals. of water. It proved fatal to both the cabbage plants and the insects.

Naphthaline.

In 1890, Prof. J. B. Smith reported an experiment by one of his correspondents with this substance. In its crude form it injured the plants severely, even more than did the purified form. It killed the maggots. Perhaps the substance will prove of value if applied in the soil with the McGowen Injector.

BIBLIOGRAPHY AND SYNONOMY.

Phorbia brassicae Bouché.

- 1833 Bouché, Naturgeschichte der Garten-Insekten, p. 131, *Anthomyia*.
Original description. Adults and larvae briefly described, and remedies discussed.
1834. Bouché, Natur. der Gart.-Insek. bes. als Larven u. Puppen, p. 73.
Detailed desc. of larva, pupa, and both sexes of the adults.
1837. Westwood, Gardener's Mag., XIII, 241. Mentioned.
Kollar, Natur. der schäd. Insecten. Gives Bouché's original article.
1840. Loudon, Insects Inj. to Gard. etc., p. 159. Literal translation of Kollar's account.
Westwood, Class. of Insects, II, 570. Mentioned.
1841. Curtis ("Ruricola"), Gardener's Chron. p. 296. Comparison of adults with those of *P. ceparum*.
1843. Curtis, Jour. Royal Agr. Soc. of Eng., IV., 127-131. Same as in "Farm Insects," below.
1860. Curtis, Farm Insects, p. 141. Brief account of life history; adults described; larva and pupa described briefly, with very poor figures. Remedies discussed.
1862. Schiner, Fauna Austriaca, I., 644. *A. brassicae* Bouché is doubtfully placed as a synonym of *A. ruficeps* Meigen.
1865. Taschenberg, Natur. der wirb. Thiere, p. 172-175. Life history, brief. Fairly good figures and desc. of larva and pupa; adults desc., with poor figures. Coal dust recommended.
1867. Fitch, Eleventh Report, p. 40-43. Good general account of the pest with excellent desc. of the larva and pupa.
1867. Glover, An. Rept., p. 73. Reference to Fitch's account.
1869. Fitch, Illus. An. Reg. of Rural Affairs, V, 96. General account.
Riley, First Missouri Rept., p. 156. Brief mention.
Riley, Am. Entomologist, II., 79. Mentioned.
Packard, Guide to Insects, p. 411. Brief mention.
1870. Walsh, Am. Ent., II., 137. Mentioned.
Sprague, Am. Ent., II., 302. Original account of the discovery of the Staphylinid parasite.
Glover, An. Rept., p. 66. Refers to the Staphylinid parasite.
1871. Künstler, Die Kulturpf., schäd. Insek. (herausg. von der k. k. zool.-bot. Gesellschaft), p. 38. Brief account, with remedies.
1872. Riley, Fourth Missouri Rept., p. 22 and 35. Mentioned.
Quinn, Money in the Garden, p. 93. Believes the insect causes Club Root. Recommends lime.

*As Bouché's, *brassicae* has always been referred to this genus, it will be unnecessary to repeat this generic name for each author cited.

1874. Glover, Manuscript Notes on Diptera, p. 2. References
 Le Baron, Fourth Rept., p. 67. Staphylinid parasite mentioned.
 Kaltenbach, Pflanzenfeinde, p. 34. Brief.
 Cook, Rept. Mich. Board of Agr., p. 119. Mention.
1877. Riley, Ninth Missouri Rept., p. 95. Mentioned; says that doubtless several of the species affecting onion, radish, etc., constitute but one species.
1878. Osten Sacken, Cat. of Diptera of N. Amer., p. 167. References.
 Riley, Rept. of U. S. Entomologist, p. 208. Mentioned.
1880. Taschenberg, Prak. Insek.-kunde, part IV, p. 128. Similar to his account published in 1865.
 Barnard, Am. Ent., III, 199. Note on predaceous habit of Staphylinid beetle.
 Cook, Am. Ent., III., 263. First published account of his experiments with Carbon Bisulphide.
1881. Schmidt-Göbel, Die Schäd. Insecten des Land-u. Garthenbaues, part 2, p. 134. Similar to Taschenberg's account; the male and female are fairly well represented by colored figures
1882. Lintner, Can. Ent., XIV., 96-97. Mentioned. (Same article in Thirteenth An. Rept. Ent. Soc. Ont., p. 29.)
 Lintner, First Report, pp. 47, 171, 184-191, 192, 193. Very good general account of the habits, life history, and enemies of the insect, with discussion of remedies.
 Ormerod, Rept. for 1881, p. 8-10. General account with discussion of remedies.
1883. Ormerod, Rept. for 1882, p. 10. Mention.
 Cooke, Inj. Insects, p. 321. Brief.
1884. Riley, Rept. of U. S. Entomologist, p. 319-321. Good general account of the past history, habits, and enemies of the pest, with a discussion of the remedies recommended. Best figures of the larva, pupa, and adult before published.
 Ormerod, Rept. for 1883, p. 10-17. Quotes Taschenberg on life history, and discusses remedies.
 Lintner, Count. Gent. LXIX., p. 677. Mentioned.
1885. Lintner, Second Rept., p. 28. Mentioned.
 Lintner, Count. Gent., I., p. 574. Discussion of remedies.
 Saunders, Can. Ent., XVII., p. 236. Brief general account.
1886. Leunis, Syn der Thierkunde, II., p. 429. Fly described.
 Goff, Fourth Rept. N. Y. State Agr. Expt. Sta., p. 221. Careful experiments with kerosene emul. and mercury.
 Fletcher, Rept. for 1885, p. 18. Extent of damage.
 Saunders, Rept. Ent. Soc. Ont. for 1885, p. 5. Brief.
 Cook, Rept. Mich. Bd. Agr., p. 39. Expts. with carbolic acid emulsion.
1887. Lintner, Thirty-ninth An. Rept. N. Y. Mus. Nat. Hist., p. 123 (also in his Fifth Rept. p. 265). Reports attack on cauliflowers.

- Lintner, New Eng. Homestead, XXI., p. 136. Very good discussion of the remedies that have been recommended.
- Coryell, Pop. Gardening, II., p. 106. Brief account.
- Cook, Rept. Mich. Bd. Agr., p. 42. Expts. with various insecticides. Account of mite eating the eggs of the pest.
- Cook, *ibid.* p. 449-450. Details of his expts. to show that the radish, cabbage, and onion maggots are the same species or else varieties of the same. Remedies discussed.
1888. Goff, Sixth Rept. N. Y. State Agr. Expt. Station, p. 96-97. Careful experiments with lime and saltpetre.
- Gillette, Can. Ent., XX., p. 133. Mite feeding on the eggs.
- Fletcher, Rept. for 1887, p. 22. Brief account with discussion of remedies.
- Cook, Bulletin 39 of Mich. Expt. Station (also in Rept. Mich. Bd. of Agr. for 1888, p. 225), p. 10. Expt. with carbolic acid and plaster, and other remedies discussed.
- Hulst, Bulletin 46 of the N. J. Expt. Station, p. 7. Brief account; carbon bisulphide advised.
- Hulst, Bulletin 50, N. J. Expt. Station, p. 12-13. Life history brief. Kerosene emulsion recommended; carbon bisulphide injured roots.
1889. Goff, Seventh Rept. N. Y. State Agr. Expt. Station, p. 147. Careful expts. with several insecticides.
- Lintner, Fifth Rept., p. 158-159. Very good discussion of preventives.
- Zimmer Bros., Insect Life, I., 15. Successful with kerosene emulsion.
- Cockerell, Insect Life, II., 146. Reported as injuring turnips in Colorado.
1890. Ormerod, Manual of Inj. Insects, p. 25. Life history, brief; with full discussion of remedies.
1891. Coquillett, Insect Life, III., 318. Mention of *Aleochara* parasite.
- Fletcher, Rept. for 1890, p. 161-165. The best account of the habits, life history, and enemies of the pest, including a discussion of remedies, that I have seen.
- Fletcher, Bulletin II., Ottawa Expt. Station, p. 26. Brief account.
- Fyles, Rept. Ent. Soc. Ont., XXI., p. 44. Mentioned. *Ibid.*, p. 45. Brief account.
- Weed, C. M., Insects and Insecticides, p. 188-190. Good general account, with remedies.
- Crozier, The Cauliflower, p. 96. Life history, brief (from Lintner), with discussion of remedies.
1892. Weed, H. E., Bulletin 21, Mississippi Agr. Expt. Station, p. 15, Life history, brief. Recommends hellebore and kerosene emulsion.
- Goff, Eighth An. Rept. Wisconsin Agr. Expt. Station, p. 169-173. Life history, brief. Detailed account of the origin and use of his tarred paper pad preventive.
1893. Lintner, Proc. Western N. Y. Hort. Soc., p. 38 (also in his Ninth Rept., p. 431). Reference to Goff's pad preventive.

- Whitehead, Rept. for 1892, p. 18-19. Life history, brief; with discussion of remedies. Poor colored figures of adult, pupa, and larva.
- Riley and Howard, Insect Life, V. 293. Review of Whitehead's Rept.
- Ormerod, Rept. for 1892, p. 146. Brief account, with discussion of remedies.
- Alwood, Bulletin 24, Virginia Expt. Station, p. 12. Brief account; advises rotation of crops, and the use of kerosene emulsion.
- Evans, Handbook of Expt. Station Work, p. 47. Brief account, with remedies.
- Bethune, Rept. Ont. Ent. Soc. for 1892, p. 9. Brief account.
1894. Sempers, Injurious Insects, p. 136. Abstract of C. M. Weed's account.
- Butz and Baldwin, Rept. Pennsylvania Expt. Station for 1893, p. 130. Expt. with Slacked lime and Soot.
- Smith, Rept. N. J. Expt. Station for 1893, p. 534. Mentioned, with Riley's figures of the larva, pupa, and adult; and an original figure of the mouth parts of the larva.
- Goff, Tenth Rept. Agr. Expt. Station of Wisconsin, p. 259-261. Records successful expt. with tarred paper pads.

floccosa Macquart.

1835. Macquart, Hist. Nat. des Insectes. Dipteres, II, 326. Original description. *Chortophila*.
1878. Meade, Ent. Mo. Mag., XIV, p. 250. Records finding a specimen in a Coll. of Anthomyiidae received from Cambridge Museum. *Chortophila*.
1881. Hagen, Can. Ent., XIII., 49. Records Mead's note on specimen found in the Cambridge Collection. *Chortophila*.
- Inchbald, The Entomologist, XIV., 290. Bred the insect from young Savoy's. *Chortophila*.
1882. Lintner, Can. Ent., XIV., 96. Records the insect as a Beet Leaf-miner. *Chortophila*. (Same article in Rept. Ont. Ent. Soc. for 1882.)
- Lintner, First Rept., p. 207-208. Description of the insect as a Leaf-miner of Beets. *Phorbia*.
1883. Verrall, Ent. Mo. Mag., XIX., 224. Records it from the Island of Arran; and places *villipes* Zett. as a synonym. *Chortophila*.
- Meade, Ent. Mo. Mag., XIX., 214. Detailed descriptions. *Phorbia*.
1888. Stein, Entomologische Nachrichten, XIV., 370. Records the species as common throughout the summer in Saxony; and says it is synonymous with *floralis* Fall. *Chortophila*.
1892. Stein, Ent. Nachrichten, XVIII., 324 and 326. From an examination of type specimens in the "Fallen-Zetterstedt Collection" the author concludes that *Aricia villipes* Zett. = *C. floccosa* Mcq.; and that *floralis* Fall. is distinct from *floccosa* Mcq. The author is familiar with *floccosa*, and points out the difference between the two species; he records the capture of three specimens of *floralis* in August of that year.

1893. Meade, Ent. Mo. Mag., XXIX., 219. Comments on Stein's paper, and accepts *villipes* Zett. = *floccosa*; but says nothing of Stein's separation of *floccosa* from *floralis* Fall.

Phorbia floralis Fallén.

of Meigen, Zetterstedt, Schiner, and others.*

1826. Meigen, Syst. Besch. Insek., V., 165. Description of adults.
 1834. Bouché, Natur. der Insek., bes. als Larv. u. Pup., p. 77. Larva and pupa described.
 1845. Zetterstedt, Dipt. Scand., IV., 1536, 147. Description.
 1853. Walker, Insect. Brittan., Diptera, II., 142. Describes it as common in England.
 1862. Schiner, Fauna Austriaca, I., 646. Description from a Zetterstedt type specimen.
 1872. Weyenbergh, Tijds. voor Ent. Nederl. Ent. Ver. Leiden, 2d ser., VIII., p. 131. Descriptions of the different stages, with habits and life history as a Radish pest. One plate of fairly good figures.
 1880. Taschenberg, Prak. Insektenkunde, part IV., p. 132. Describes adults, and compiles Bouché's descriptions of the larva and pupa. (Bouché, however, does not say: "Also stark schwarz gekörnelt").
 1882. Lintner, First Rept., p. 207. Mentioned.
 1883. Meade, Ent. Mo. Mag., XIX., p. 214. Mentioned.

villipes Zetterstedt.

1883. Ormerod, Rept. for 1882, p. 10. Brief account.
 1884. Ormerod, Rept. for 1883, p. 10-17. Brief account of life history, with general discussion of remedies.
 1890. Ormerod, Man. of Inj. Insects, p. 25. Brief account.
 1893. Ormerod Rept for 1892, p. 146. Brief account.
 1845. Zetterstedt, Dipt. Scand., IV., 1456, 67. Original description.
 1862. Schiner, Fauna Austriaca, I., 650. Quotes Zetterstedt.
 1883. Verrall, Ent. Mo. Mag., XIX., 224. Places *villipes* as a synonym.
 1892. Stein, Ent. Nachr., XVIII., 324. Synonym.
 1893. Meade, Ent. Mo. Mag., XXIX., 219. Mentioned.

* In 1883, Meade had but little doubt that *floccosa* Macq. was the same as the *M. floralis* of Fallén, Meigen, Zetterstedt, Schiner, and others; and (notwithstanding Stein's separation of the species based upon an examination of Fallén's type) August 31, 1894, he writes me that he thinks that the *floralis* of Fallén, Meigen, and Zetterstedt is the same as *floccosa* Macq. I believe the *floralis* of the authors mentioned above and others, except Fallén, is the same as *brassicæ* Bouché; therefore such references are here given a place in the synonymy. Fallén described his *floralis* in 1824 (Monog. musc. Sueciæ, part VII., p. 71, No. 76. In Hagen's Bib. Ent. the date of this part is given as 1824, but Schiner quotes 1820). Meigen's description antedates Bouché's *brassicæ* by 7 years; but, as Stein has shown, *floralis* is now occupied in the same genus by *floralis* Fallén, thus the rules of nomenclature require us to accept Bouché's name, even though Meigen described the same insect under another name several years before. Macquart's *floralis* seems to be different. All the authors refer the species to genus *Anthomyia*.

Anthomyia radicum Linnaeus.

of Curtis and others.

1843. Curtis, Jour. Roy. Agr. Soc. of Eng., IV., 127-131. Same as in "Farm Insects," below.
1860. Curtis, Farm Insects, p. 141. Brief account, including description of adult and larva, with figure of adult; Mr. Meade writes me recently that this is a very good figure of *P. floccosa*. The same figure is used by most of the following authors; all use the generic name *Anthomyia*.
1867. Fitch, Eleventh Rept., p. 40. Is unable to distinguish between this species and *brassicae*.
1875. Packard, Rept. U. S. Geol. Surv., p. 762. Credits the species to Bouché, with Harris' *raphani* as a synonym. Brief account with remedies.
1880. Saunders, Can. Ent., XII., 212. Bred from young cabbage. (Also in Rept. Ont. Ent. Soc. for 1880, p. 10).
1882. Lintner, First Rept., pp. 171, 184, 186, 191-194, 196, 198. Good general account, mostly from Curtis and Fitch, with Curtis' figure.
1885. Goff, Third Rept. N.Y. State Agr. Expt. Station, p. 316. Experiments with Carbon Bisulphide on radishes.
1891. Fletcher, Bulletin 11, Ottawa Expt. Station, p. 29. Brief with remedies.
- Fyles, Rept. Ent. Soc. Ont., for 1890, p. 44. Brief account as turnip pest.
- raphani* Harris.
1835. Harris, Cat. of Animals and Plants of Mass., p. 80. Name, but no description. Is always referred to the genus *Anthomyia*.
1841. Harris, Insects Inj. to Veg., p. 494. Brief account. (In Flint Edition of 1862, p. 616.)
1858. Osten Sacken, Cat. of Diptera of N. Am., p. 74. Mentioned.
1867. Fitch, Eleventh Rept., p. 59-61. Very good account with careful descriptions. Says it appears to be identical with *radicum* (which he fails to separate from *brassicae* on p. 41.)
- Glover, Rept. for 1867, p. 73. Reference to Fitch's account.
1869. Fitch, Illus. An. Reg. of Affairs, v. 96.
- Packard, Guide to Insects, p. 411. Brief.
1870. Trimble, Am. Ent., II., 273. Notes on habits and life history.
- Riley, Am. Ent., III., 284. Recommends hot water.
1872. Glover, An. Rept., p. 134. Mention.
- Quinn, Money in the Garden, p. 218. Brief account.
1874. Glover, Man. Notes on Diptera, p. 3. Reference.
- Cook, Rept. Mich. Bd. Agr., p. 121. Life history, brief; with remedies.
1877. Riley, Ninth Missouri Rept., p. 95. Mentioned.
1878. Osten Sacken, Cat. of N. Am. Diptera, p. 168. References.
1881. Cook, Can. Ent., XIII., p. 198. Carbolic acid as preventive. (Also in Rept. Mich. Hort. Soc. for 1881, p. 213, and in Rept. Ont. Ent. Soc.

- for 1881, p. 26. Paper was first read before the Am. As. Adv. Sci. at Cincinnati, O.)
1883. Reed, Rept. Ent. Soc. Ont. for 1882, p. 53. Mentioned.
Cooke, Inj. Insects, p. 328. Brief account.
1884. Lintner, Count. Gent., LXIX., p. 677. Mentioned.
1885. Goff, Third An. Rept. N. Y. State Agr. Expt. Station, p. 196. Careful experiments against.
Lintner, Second Rept., p. 28. Mentioned.
1886. Goff, Fourth An. Rept. N. Y. State Agr. Expt. Station, p. 222.
Experiments with carbolic acid.
Fletcher, Rept. for 1885, p. 15. Life history, brief, with good discussion of remedies.
- Cook, Rept. Mich. Bd. Agr., p. 38 and 39. Experiments with kerosene and carbolic acid emulsions.
1887. Cook, Rept. Mich. Bd. Agr., p. 42. Negative experiments with several insecticides.
Cook, *ibid.* p. 449-450. Details of experiments to show that the onion, cabbage, and radish maggots are the same species or varieties; and conclusions regarding remedies.
1888. Gillette, Can. Ent., XX., 133. Parasite.
Fletcher, Rept. for 1887, p. 23. Brief account, with good discussion of remedies.
- Hulst, Bulletin 50, N. J. Expt. Station, p. 12. Mentioned.
1891. Fyles, Rept. Ont. Ent. Soc. for 1890, p. 454. Good account of habits.

In the following references the scientific name of the insect is not mentioned; the pest is designated by one of its common names, this depending upon the plant attacked, as the Cabbage, the Cauliflower, the Turnip, or the Radish Fly or Maggot.

1846. Kirby and Spence, Int. to Ent., p. 140. Infesting Cauliflowers.
1857. Saunders, Edgar., Count. Gent., p. 319. Recommends tobacco dust. Cabbage Fly.
"T.", *ibid.* p. 47. Success with Superphosphate of Lime; negative results with other substances. Cabbage Fly.
1858. Editorial in Count. Gent., p. 26. Thinks Clump-rooted cabbage caused by fly. Radish and Turnip maggots mentioned.
Henderson, *ibid.*, p. 159. Thinks "Club-foot" caused by fly, and advises lime.
1859. Count. Gent., p. 127. Says tobacco water kills. Cabbage Maggot.
1861. Gregory, Count. Gent., p. 319. Advises lime for Cabbage Maggot.
1864. Count. Gent., p. 224. Turn the chickens into the patch for the Cabbage Fly.
Editorial in Count. Gent., p. 65. Says a contemporary recommends corrosive sublimate for Cabbage and Cauliflower Maggots; should first be well tried.

1869. Riley, First Missouri Rept., p.156. Radish Maggot mentioned.
1872. Brill, Farm Gardening and Seed Growing, p.20-21. Maggots as the cause of "Club-root" in Cabbages, Cauliflowers, etc. Believes the Cabbage and Radish Maggots are the same.
1875. "J. H. G.", Count. Gent., p.392. Asks for a remedy for Cabbage Maggots.
- "W. F. P.", *ibid.* p.454. Kills Cabbage Grub with soap and water.
- Editorial in *ibid.* p.488. Quotes Henderson that "Club-foot" is caused by an insect.
- Philbrick, *ibid.*, p.505. Says it is not generally believed that "Club-foot" is caused by an insect, also that bone dust does not prevent; says rotate crops.
1877. "W. H. J.", Count. Gent., p.236. Nearly two acres of cabbage destroyed by maggot; ruta bagas along side also attacked.
- Garfield, Chas. W., Rept. Mich. Bd. Agr., p.61. Careful expts. with insecticides for Cabbage, Radish, and Turnip Maggots.
1879. Talcott, Count. Gent., p.85. Lost his whole turnip crop in 1878 and inquires for a preventive of the Turnip Fly.
- "W. H. J.", *ibid.*, p.151. In answer to Talcott, says the Cabbage Maggot has conquered them.
- "C. D. A.", *ibid.*, p.167. Says Mr. Will used salt successfully.
- Philbrick, *ibid.*, p.183. Says the Maggots have nothing to do with the "Club-foot" Mentions Tillinghast's theory in regard to the life history of the maggot. Only remedy is to destroy the eggs by rubbing the stems.
- Tillinghast, *ibid.*, p.774. Discusses the theory of "Club-foot."
- Henderson, *ibid.*, p.807. Strongly advises lime, and reiterates his belief that the "Club-foot" is caused by the maggot.
1880. Philbrick, Count. Gent., p.23. Has found maggots in great abundance where there was no "Club-foot."
- Hewes, *ibid.*, p.39. Says salt prevents "Club-foot" as the maggot cannot live in it.
- Tillinghast, *ibid.*, p.438. Says that no one has disproved his theory that the maggots are the larvae of the Striped Flea Beetle.
- West, *ibid.*, p.470. Thinks "Club-foot" due to maggot. Negative expt. with salt, lime, and bone dust. Answers Tillinghast by breeding the perfect insect—a fly.
1881. Cook, Proc. A. A. A. S. for 1880, p. 669-670. First account of use of Carbon Bisulphide against the Cabbage Maggots.
- "E. L. C.," Am. Cultivator, for April 30. Says that soot is good, and strongly recommends Corrosive Sublimate. Cabbage and Cauliflower Maggot.
- "Horticola," Rur. N. Yorker, p. 465. Recommends puddling in lime and soot for Cabbage Maggot.
1883. Barnard, Proc. Biol. Soc. Wash., Dec., 1883. (Account in Psyche,

- IV., pp. 134, 143., describes his "Nether-inserter" and its use against various insects, the Cabbage Maggot included.
1884. Cook, Rept. Mich. Hort. Soc., p. 204. Soap and kerosene for *Anthomyiids*, with instrument for applying the liquid.
1885. Lintner, Second Rept., p. 35. Reference to Barnard's "Nether-inserter" for Cabbage Maggot.
- Fletcher, Rept. for 1884, p. 6. Reports Cabbage Root-fly very injurious.
- 1886 Fletcher, Rept. for 1885, p. 6. Cabbage Maggot reported in Ontario and Vanc. Island
- Fletcher, *ibid.*, p. 15. Habits of a Turnip Maggot, *Anthomyia* sp.
- Cook, Rept. Mich. Bd. Agr., p. 38. Experiments with kerosene emulsion against the Radish Maggot.
- Cook, *ibid.*, p. 41. Experiments against the Cabbage and Radish Maggots with several insecticides.
- Cook, Rept. Mich. Hort. Soc., p. 523. Says kerosene emulsion and carbon bisulphide will surely kill. Gas lime also effectual. How to use the two former. Art. by Henderson quoted from Rural N. Yorker, in which he says lime and guano are only effective on the early stages of the Maggots. Radish and Cabbage Maggots.
- "C. E. P.," Rur. N. Yorker, p. 254. Recommends concentrated fertilizer in hill. Cabbage Maggot.
- Rur. N. Yorker, p. 338. Answer to "M. M. L." Advises lime and any concentrated fertilizer. Cabbage Maggot.
- Ibid.*, p. 643. Answer to "W. J. P.," advises sandy soil for Radish Maggots.
- "J. H.," Rur. N. Yorker, p. 840. In trying to kill Cabbage and Cauliflower Maggots by puddling plants in Insect Powder and Paris Green, the plants were killed.
1887. Henderson, Gardening for Profit, p. 319. Says the insect is the cause of "Club-foot." Expt. with manure and bone dust. Curious theory of the life history of the Cabbage Maggot.
- Henderson, Rur. N. Yorker, p. 133. General account of Cabbage Maggot, with an expt. with guano and cotton seed meal fertilizers
- "N. W. S.," Rur. N. Yorker, p. 234. Advises Henderson to use Kainit, but says it will not affect the maggot after it has hatched.
- Perkins, Rur. N. Yorker, p. 431. Tells how he kills Cauliflower Maggots with Liver of Sulphur.
- "H. A. M.," Rur. N. Yorker, p. 530. Says Cook's emulsion cost him 2000 cauliflower plants. Now hires women to haul the eggs and young larvae into the middle of the rows where they perish.
- Hoskins, Rur. N. Yorker, p. 542. Recommends lime for Cabbage Maggot.
- Perkins, *ibid.*, p. 626. Again details his expts. with Liver of Sulphur.
- Henderson, *ibid.*, p. 578. Says he feels certain that "nothing will kill the Cauliflower maggot, which will not at the same time kill the plant." Says "H. A. M.'s" plan was adopted by them several years before, and it is the only thing that will save the crop.

- Goff, *ibid.*, p. 135. Advises sandy soil to prevent Radish Fly.
- Rur. N. Yorker, p. 154. In answer to 'J. J. C.," advises Kainit to destroy Cabbage Maggots.
1888. Rur. N. Yorker, p. 149. Negative results with lime and nitrate of potash against Cabbage Maggots.
- Goff, Sixth Rept. N. Y. State Agr. Expt. Station, p. 96. Negative result with lime for Cabbage Maggot.
- Cook, Rept. Bd. Agr., p. 43. Saved radishes by a protection; has further proof that Onion, Cabbage, and Radish Maggots are identical. Radishes as trap crop.
- Cook, Bulletin, 39, Mich. Expt. Station, p. 10. (Also in Rept. Bd. Agr., p. 225.) More convinced that Cabbage, Radish, and Onion Maggots are the same. Advises radishes as trap crop.
- Howard. G. H., in Burpee's How to Grow Cabbage and Cauliflower, p. 47. Says muriate of potash and wood ashes are sure remedies.
- Fletcher, Rept. Ont. Ent. Soc. for 1887, p. 14. Carbolic acid and gas lime for root maggots of Radish and Cabbage.
- Fernald-Maynard, Rept. Mass. Bd. Agr. for 1887, p. 94. Brief.
1889. Lintner, Count. Gent., p. 440. Discussion of remedies for Cabbage Maggot on Cauliflower.
- Dunning, Pop. Gardening IV., 24. Expt. with liquid manure and lime for Cabbage Maggot.
- Riley and Howard, Insect Life, II., 86. Ref. to Dunning's expt.
- Rur. N. Yorker, p. 495. Ref. to Dunning's expt.
- "H. A. M.," Rur. N. Yorker, p. 678. Expt. with Sulphur.
- Fletcher, Rept. for 1883, p. 68. Mention of Cabbage Anthomyia.
1890. Greiner, How to Make a Garden Pay, p. 98. Considers the Cabbage, Radish, Turnip, and Onion Maggots the same insect. Radishes preferred. Remedies discussed.
- Smith, Bulletin 75, N. J. Agr. Expt. Station, p. 12. Expt. with kainit against Cabbage Maggot. P. 20, expt. with naphthaline against Radish Maggot. P. 26, expt. with kerosene emulsion on Radish Maggots. P. 29, expt. with Hellebore for maggots.
1891. Riley and Howard, Insect Life, III., 247. Hellebore for Cabbage Root-maggot.
- Fletcher, Insect Life, IV., 13. Late planting for Cabbage Maggot.
- Schwarz and Fletcher, Insect Life, IV., 27. Discussion of the parasitic habits of *Aleochara*, which Fletcher bred from Cabbage Maggot.
- Smith, Bulletin 85, N. J. Expt. Station, p. 8. Discussion of merits of tobacco, kainit and nitrate of soda for Radish and Cabbage maggots.
- Weed, Insects and Insecticides, p. 188. Radish Maggot mentioned.
- Crozier, The Cauliflower, p. 96. Radish maggot mentioned.
1892. Rawson, Suc. in Mark. Gardening, p. 228. Radish Maggot prefers radishes to cabbage, cauliflower, or onions. Advises lime, and says kainit or muriate of potash kills eggs and maggots by contact.
- Barnhardt, Insect Life, V., 136. Expt. with carbon bisulphide for Cabbage maggot.

- Forbes, Insect Life, V., 74. Cabbage Maggot mentioned.
- Smith, Insect Life, V., 94. Mention of Cabbage and Cauliflower Root-maggots.
- Fletcher, Insect Life, V., 124. Hellebore and kerosene emulsion successful in gardens, but not in field, for Cabbage, Radish, and Turnip Maggots.
- Weed, H. E., Bulletin 21, Miss. Agr. Expt. Station, p. 15. Radish Maggot mentioned.
1893. Lintner, Ninth Rept., p. 418. Kainit for Cabbage Maggot.
- Fletcher, Rept. for 1892, p. 145. Similar to account in 1892, above.
- Smith, Rept. N. J. Expt. Station for 1892, p. 391. Recommends hellebore for Cabbage and Cauliflower Root-maggots.
- Smith, Insect Life, VI., 96. Reference to Fletcher's use of hellebore for Cabbage Maggot.
1894. Fletcher, Rept. for 1893, p. 19. Cabbage Maggots mentioned. (Also in Rept. Ont. Ent. Soc. for 1893, p. 10.)
- Washburn, Bulletin 31, Oregon Expt. Station, p. 82. Expt. with lime, ashes, and tobacco water on Radish and Turnip Anthomyiids.
- Notes on the above Synonymy and Bibliography.*—Although containing over 230 references, the Bibliography is incomplete. The pest is so well known, so widely distributed, and so destructive that it has attracted much attention for more than 50 years; and in consequence it has been often discussed in our economic entomological literature and in Agricultural periodicals. I have had access to nearly all of the strictly entomological publications of the United States, but I have seen only a few complete files of agricultural publications (the *Country Gentleman* is the only weekly general farm paper among these). The reports in these periodicals are often valuable, as they usually give the results of experiments with various substances; thus it is to be regretted that this part of the bibliography could not be made more complete. It is also incomplete in respect to foreign publications as only those are included to which I have had access. I believe, however, the bibliography contains nearly all of the more important articles on this pest in the world's literature.

Economic writers on the pest have heretofore paid little or no attention to the systematic phase of the subject. Nearly every economic writer, whether European or American, has used, scarcely without question, the name *brassicae*, given to the insect by Bouché in 1833; while Schiner is the only Dipterologist, so far as I know, who has expressed any opinion on Bouché's species. However, the flies, which I bred in large numbers from Cabbage Maggots, were determined by Mr. Meade as *Phorbia floccosa* Macq. Coupled with this fact, I soon found that all the specimens of Cabbage, Cauliflower, Radish, or Turnip Maggots or Flies to which I could get access through entomological friends,* belonged to this same species—*floccosa*. These facts at once

*Messrs. G. C. Davis, J. Fletcher, L. O. Howard, and Dr. Lintner have kindly sent me their material in this line for study. This has enabled me to settle many disputes and unsolved questions.

caused me to wonder if all these years this common pest has been discussed under the wrong name. After a laborious critical study of all accessible descriptions and accounts of the insect, with my specimens always at hand, I have reached the conclusion that the Cabbage Maggot should be called *Phorbia brassicæ* Bouché.

Realizing the responsibility incurred by the wide divergence from the opinions of systematists which my synonymy represents, I deem it necessary to offer a detailed explanation of the facts from which I reached my conclusions. For 50 years past, so far as I can discover, every economic writer, whether American or European, has called the Cabbage Maggot *Anthomyia brassicæ* Bouché. But I have found only two or three references to Bouché's species in the systematic literature of the Anthomyiians. Westwood, Osten Sacken, and Leunis apparently accepted *brassicæ* Bouché without question; but Schiner thought it probably identical with *ruficeps* Meigen. Later Dipterologists seem to have overlooked the species entirely.* Naturally the question arose: What is *Anthomyia brassicæ* Bouché.

Mr. Meade answers the question for me in a recent letter as follows: "There is no doubt that the true Cabbage Fly is the *Phorbia floccosa* of Macquart, but this species has been confounded with *Anthomyia radicum* Linn. . . . I have no doubt that Bouché confounded *P. floccosa* and *A. radicum* together. . . . I am convinced that Bouché, Curtis, Zetterstedt, and others did not know the difference between these two species and confounded them together." The question is answered by Mr. Stein in a recent letter to me, thus: "I believe that *Phorbia floccosa* Macq., Rond., Mde. and *A. brassicæ* Bouché are synonymous. The first name has the priority." I had reached the conclusions represented in my synonymy before receiving either of the above answers; and after a careful review of the whole subject, I still adhere to the same opinions.

I believe with Mr. Stein that *floccosa* Macq. and *brassicæ* Bouché are synonymous; but Macquart's description did not appear until 1835,* while Bouché had twice described his *brassicæ* before this. His first description in 1833 is brief, but the next year it was given in detail and both accounts are accompanied by accurate descriptions of the larva and puparium. Bouché's *brassicæ* thus has the priority over *floccosa* Macq.

I believe with Mr. Meade that *floccosa* Macq. has been confounded with *radicum* Linn. by some authors, as my synonymy shows. But I do not think that Bouché confounded them. It is true that Bouché describes only the larva and puparium of *radicum*, but he makes these entirely distinct from his *brassicæ*, thus indicating that he knew *radicum* Linn. All European authors

*There is an older *Anthomyia brassicæ* described by Wiedemann several years before Bouché published his description. However, Wiedemann's species was soon placed in the synonymy of *A. radicum* Linn. by Meigen seven years before Bouché wrote; and this synonymy has been accepted by Schiner and Meade.

*I have examined his earlier work on the "Insectes Dipteres du Nord de la France (1826-1834)" and find no reference to *floccosa*; and all the references to *floccosa* I have seen refer to his later work (1835) for the original description

seem to have accepted Bouché's descriptions of the early stages of *radicum*, for their accounts are but compilations from Bouché. I think a careful comparison of Bouché's descriptions of the adults of his *brassicæ* with specimens of *floccosa* Macq. will convince any fair critic that he had Macquart's species, and not *radicum* Linn., before him. I believe Bouché saw the characteristic tuft of hairs on the hind femora, for he says: "Schenkel aussen vielborstig;" no similar expression occurs in his descriptions of any other Anthomyiian. A further strong argument for the validity of Bouché's species is to be found in the accurate detailed descriptions of the larva and puparium. These descriptions of the early stages of the pest are the models from which nearly all of the later accounts have been taken; the careful descriptions of Dr. Fitch are the only notable exceptions of original work. Westwood has testified to Bouché's capabilities and abilities for observation (Gard. Mag. for 1837, p. 243.) Furthermore, I think but few authors have confounded *radicum* Linn. and *floccosa* Macq. A study of the descriptions of *radicum*, *brassicæ*, and *floccosa* in the works of Meigen, Bouché, Macquart, Walker, and Schiner shows that in every case the abdomen of the male insect of *radicum* is described as sub-elliptical (Mr. Meade says: "short, wide, somewhat pointed"). While all the descriptions of either *floccosa* or *brassicæ* agree that the male abdomen is sub-cylindrical, "streifenförmig," or long and narrow. Macquart puts *radicum* and his *floccosa* in different groups on this difference in the shape of the abdomen. I have not seen Zetterstedt's work. In 1867, Dr. Fitch pointed out that the slight difference indicated by Curtis between *brassicæ* Bouché and the species supposed by Curtis to be *radicum* Linn. were hardly more than accidental and not of sufficient value to indicate a specific difference between the insects. In a recent letter Mr. Meade incloses Curtis' figure of *radicum* with the remark that "it gives a very good figure of *P. floccosa*." I have never seen a specimen of *radicum* Linn., and the only authentic record that the species occurs in this country is the fact that a specimen was found in the Cambridge Collection by Mr. Meade in 1878. From the above evidence, the only conclusion I can reach is that *brassicæ* Bouché is a valid species, has priority over *floccosa* Macq., and is the name to be applied to the Cabbage Maggot unless some other name appears which antedates it.

In 1883, Mr. Meade stated in his description of *floccosa* Macq. that "there is but little doubt that this species is the same as the *M. floralis* of Fallén, Meigen, Zetterstedt, Schiner, and others; for the general descriptions of both species agree together, though none of the last-named authors mention the tufted femora." In a recent communication to me Mr. Meade reiterates the same opinion. However, Mr. Meade has not yet, in print, removed the question mark from his reference of *floralis* to the synonymy of *floccosa*. In 1882, Miss Ormerod had specimens of the Cabbage Maggot Fly determined by Mr. Meade, and she has since used the name *Anthomyia floralis* Fallén. This possible identity of these two species is a very important question, for *floralis* antedates Bouché's *brassicæ* by several years. Thus, if their identity could be shown beyond a doubt, the Cabbage Maggot would have to be called *Phorbia floralis* Fallén.

I do not know who first suspected the identity of *floccosa* and *floralis*. I have seen no record earlier than Mr. Meade's. In 1888, Mr. Stein recorded "*Ch. floccosa* Macq. (= *floralis* Fall.) common throughout the whole summer." Four years later, however, Mr. Stein critically examined the Fallén-Zetterstedt Collection at Lund and has published (Ent. Nach., xviii, 326) the following account of a species which he found in the collection under the name *A. floralis* Fall.: "*A. floralis* (147) Ich habe diese Art mit andern dipterologischen Freunden bisher für identisch mit der überall gemeinen *Ch. floccosa* Macq. Rd. gehalten und glaube auch, dass Schiner bei Beschreibung seiner *A. floralis* letztere vor sich gehabt hat; er sagt zwar in der Anmerkung, dass er ein Zetterstedt'sches Originalstück gehabt habe, doch ist dem kein Wert beizulegen, da ja Zetterstedt die Arten oft genug verwechselt hat. Die Fallén'sche Type von *M. floralis* ist, wie mich der Augenschein gelehrt hat, verschieden von *Ch. floccosa*, wenn sie auch die grösste Ähnlichkeit mit ihr hat. Sie unterscheidet sich durch die Beborstung der Hinter-schenkel, die auf der unterseite an der Basis nicht dicht und kurzborstig sind, sondern mit gleichlangen, ziemlich weitläufig stehenden Borstenhaaren besetzt sind; ausserdem ragen die Lamellen auf der Unterseite des Hinterleibs nicht hervor, wie es gewöhnlich bei *floccosa* der Fall ist. Die Fleige scheint bei uns selten zu sein, ich habe sie wenigstens zum ersten Mal in diesem Jahre im August in 3 Exemplaren gefangen. Ubrigens steckt in der Sammlung unter dem Namen *floralis* auch ein Stück von *villipes*." Mr. Stein writes me that he still holds the same opinion. This direct evidence from an examination of specimens by a Dipterologist familiar with the Anthomyiids, seems to me conclusive. Yet Mr. Meade, in commenting on Mr. Stein's paper in 1893, does not mention this important discovery, although he accepts other synonymic notes made by Mr. Stein at the time. Mr. Meade's belief in the identity of *floccosa* and *floralis* seems to be based entirely on a comparison of descriptions. One ought not to entirely ignore the direct evidence of a competent observer like Mr. Stein, so I cannot escape the conclusion that the well-known name, *brassicæ* Bouché, by which the Cabbage Maggot has been described the world over by economic writers, must be accepted, for the present at least; there is a possibility, of course, that later investigations may bring to light new evidence to show that Bouché's *brassicæ* is identical with *floralis* Fall., or perhaps some still earlier name, in which case the rule of priority would decree that the earliest name be used instead of *brassicæ*.

There is no doubt that several authors have written of the Cabbage Maggot under the name *floralis* Fall., as I have indicated in the synonymy.

In 1862, Schiner said *brassicæ* Bouché was probably a synonym of *A. ruficeps* Meigen. Could the identity of these two species be proven, Bouché's name would fall and the Cabbage Maggot be known as *Phorbia ruficeps* Meig., as Meigen's description appeared seven years before Bouché wrote. I think the facts do not warrant this conclusion of Schiner. While studying Meigen's descriptions of Anthomyiids, I was struck with the sim-

ilarity between the descriptions of his *ruficeps* and of *radicum* Linn. Careful comparison showed these descriptions to be almost identical, word for word! The only differences between the insects, indicated by the descriptions, relates to a slight difference in the coloring of the face, the scales, and the halteres; the face of *radicum* is said to be "schwarzschillernd" and the scales and halteres yellowish, while in *ruficeps* the face is "roströthem" and the scales and halteres are white (Mr. Meade describes the face of female *floccosa* as either red or black). The female of *ruficeps* was unknown to Meigen, and in fact the species does not seem to have been recognized since Meigen's time; Schiner had not seen it. Thus all the evidence I have found leads me to believe that *ruficeps* Meig. should be placed in the synonymy of *Anthomyia radicum* Linn.; at least there is scarcely a chance of its being identical with *brassica* Bouché.

My breeding experiments, and a study of flies bred from maggots infesting radishes in different parts of the country, lead me to believe that the Radish Fly or Maggot of economic entomological literature is identical with the Cabbage Maggot. A study of the literature brings out the following evidence.

European writers, following Bouché's lead, have called the Radish Fly, *Anthomyia floralis* Fallén. While American entomologists have usually adopted Dr. Harris' name, *Anthomyia raphani*; some use *radicum* Linn. Bouché's description of the larva and puparium of *floralis* Fall. agrees closely with his descriptions of the Cabbage Maggot, and with my specimens; he describes it as feeding on *Raphanus sativus*. Taschenberg compiles his descriptions of the early stages of *floralis* Fall. (as the "Rettich-fliege") from Bouché, introducing, however, the phrase "ist also stark schwarz gekörnelt," which is very misleading as can be seen by referring to the accounts of both authors. There are no specific differences between Taschenberg's descriptions of the flies of *floralis* and *brassica*. Miss Ormerod has used the name *Anthomyia floralis* Fall., the Radish Fly, since 1882 for the maggot doing the most damage to cabbage in England. Taschenberg and Schmidt-Göbel record *brassica* Bouché as attacking the various species of *Brassica*, *Raphanus sativus* and *radiola*, Turnips, and Stocks (Matthiola).

In this country, Dr. Harris gave a name to a Radish Fly in 1835, but published no description of it until 1841. None of Dr. Harris' types are known to be in existence, and no one has since definitely characterized the species as distinct from *brassica* Bouché. In 1867, Dr. Fitch was unable to separate his cabbage or turnip flies or maggots from those bred from radish, yet he described them separately as *brassica* and *raphani*. It is not until 1882 that we again find the distinctness of *raphani* seriously questioned by entomologists. Then Dr. Lintner, in discussing *raphani* thought it quite probable that it was identical with *radicum* Linn.; Dr. Fitch had reached a similar conclusion in 1867, but he was not able to separate *radicum* and *brassica*. There is a single specimen in existence labelled *raphani* by Dr. Fitch, but

it is in too poor condition to identify definitely ; yet Dr. Lintner, in a footnote gives a description of the wing venation which I think agrees closely with that of *brassica* Bouché. In 1887, Prof. Cook recorded some experiments which proved that the Cabbage and Radish Maggots would breed freely on either food-plant and were thus doubtless identical ; his conclusions from these experiments led him too far, however, for he came to believe that the maggots infesting onions (*Phorbia ceparum* Meig.), beans (*Phorbia fusciceps* Zett.), and raspberry canes (an *Anthomyiian*, possibly new) were either identical with or but varieties of *brassica* Bouché.* During the last few years, all Americans have been more and more inclined to regard the Cabbage and the Radish Maggots as identical specifically.

I think there is much in the above evidence to support the conclusion that the radish and the cabbage maggots are the same insect ; my breeding experiments and the above mentioned examination of Radish Flies from different parts of the country, also strongly support this conclusion.† Therefore, I have included all references to the Radish Fly or Maggot in the bibliography.

MARK VERNON SLINGERLAND.

* These determinations are made from specimens received from Prof. Davis, including some of the specimens bred by Prof. Cook, and from Mr. Fletcher.

† There are two other *Anthomyiians* recorded as feeding on cabbage and radish namely, *Phorbia fusciceps* Zett. and *Anthomyia radicum* Linn. The former is very common and the latter rare in this country, where I believe, however, their attacks upon cabbages or radishes are exceptional.

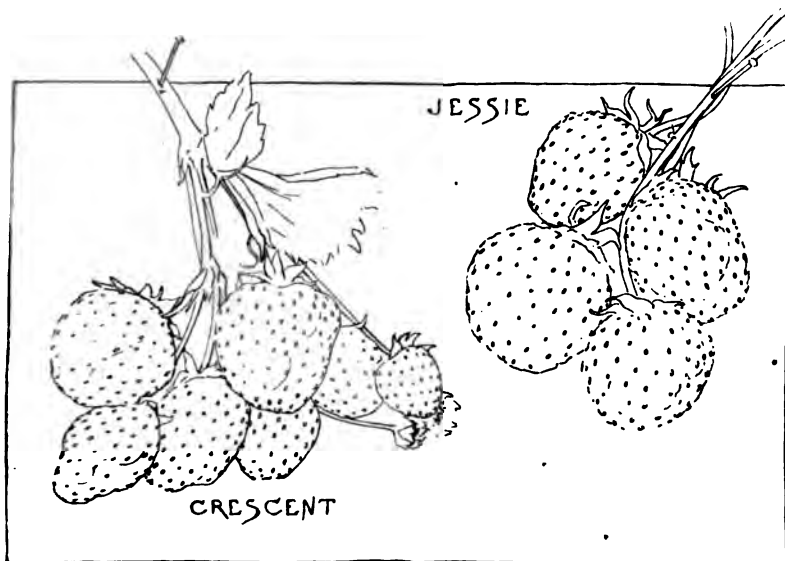
630.679
117
3286

Bulletin 79.

Cornell University Agricultural Experi.

HORTICULTURAL DIVISION.

VARIETIES AND LEAF-BLIGHT
OF THE
STRAWBERRY.



By L. H. BAILEY.

PUBLISHED BY THE UNIVERSITY,
ITHACA, N. Y.
1894.

ANIZATION.

BOARD OF CONTROL:

THE TRUSTEES OF THE UNIVERSITY.

STATION COUNCIL.

President, JACOB GOULD SCHURMAN.

Hon. A. D. WHITE,	-	-	-	-	-	Trustee of the University.
Hon. JOHN B. DUTCHER,	-	-	-	-	-	President State Agricultural Society.
Professor I. P. ROBERTS,	-	-	-	-	-	Agriculture.
Professor G. C. CALDWELL,	-	-	-	-	-	Chemistry.
Professor JAMES LAW,	-	-	-	-	-	Veterinary Science.
Professor A. N. PRENTISS,	-	-	-	-	-	Botany.
Professor J. H. COMSTOCK,	-	-	-	-	-	Entomology.
Professor L. H. BAILEY,	-	-	-	-	-	Horticulture.
Professor H. H. WING,	-	-	-	-	-	Dairy Husbandry.
Professor G. F. ATKINSON,	-	-	-	-	-	Cryptogamic Botany.

OFFICERS OF THE STATION.

I. P. ROBERTS,	-	-	-	-	-	Director.
E. L. WILLIAMS,	-	-	-	-	-	Treasurer.
H. W. SMITH,	-	-	-	-	-	Clerk.

ASSISTANTS.

M. V. SLINGERLAND,	-	-	-	-	-	Entomology.
GEO. C. WATSON,	-	-	-	-	-	Agriculture.
G. W. CAVANAUGH,	-	-	-	-	-	Chemistry.
E. G. LODEMAN,	-	-	-	-	-	Horticulture.
MICHAEL BARKER,	-	-	-	-	-	Horticulture.

Office of the Director, 20 Morrill Hall.

Those desiring this Bulletin sent to friends will please send us the names of the parties.

BULLETINS OF 1894.

62. The Japanese Plums in North America.
63. Co-operative Test of Sugar Beets.
64. On Certain Grass-Eating Insects.
65. Tuberculosis in Relation to Animal Industry and Public Health.
66. Test of Cream Separators.
67. Some Recent Chinese Vegetables.
68. The Cultivated Poplars.
69. Hints on the Planting of Orchards.
70. The Native Dwarf Cherries.
71. Apricot Growing in Western New York.
72. The Cultivation of Orchards.
73. Leaf Curl and Plum Pockets.
74. Impressions of the Peach Industry in Western New York.
75. Peach Yellows.
76. Some Grape Troubles of Western New York.
77. The Grafting of Grapes.
78. The Cabbage Root Maggot, with notes on the Onion Maggot and Allied Insects.
79. Varieties and Leaf Blight of the Strawberry.

CORNELL UNIVERSITY, ITHACA, N. Y., Dec. 10, 1894.

THE HONORABLE COMMISSIONER OF AGRICULTURE, ALBANY.

Sir.—There are two questions which the strawberry growers of western New York are always asking: What are the best varieties? How is the leaf-rust to be kept in check? I have endeavored to answer these questions, and I submit the attempt for publication under Section 87, Chapter 675, of the Laws of 1894.

L. H. BAILEY.



Parker Earle Strawberry. Introduced in 1889 by T. V. Munson, Denison, Texas, and named for Parke Earle, a distinguished horticulturist of southern Illinois and Mississippi, and president of the American Horticultural Society. An offspring of Crescent crossed with a seedling of Miner. Flowers perfect. The variety is growing in favor, particularly where a late berry is desired.

VARIETIES AND LEAF-BLIGHT OF STRAWBERRIES.

I. VARIETIES.

What varieties of strawberries shall I plant? This, and similar questions, are always asked of the experimenter, and people seem to think that it is one of the simplest questions to answer. At all events, it is the universal impression that the experiment station officer, of all others, should be able to answer it definitely. He has the facilities and the time for making tests, and it seems, upon the face of it, that he should have exact knowledge of the merits of all novelties. Yet, there are so many difficulties and uncertainties pertaining to the so-called testing of varieties that the results often possess nothing of permanent value; and there are certain reasons why the experimenter, if he derives his knowledge wholly from his own tests, is less competent to pronounce upon the merits of novelties than the grower himself.

What constitutes a test of a variety? Simply this,—obtaining exact knowledge as to whether the variety is distinct from others and whether it is useful for certain places or purposes. It would seem to be simple enough to obtain such knowledge as this; and yet it supposes that the experimenter knows all existing varieties,—which no one does or can,—and that he is equally expert in judging the merits of any and all plants which may be brought to him, from strawberries to chrysanthemums and celery to apples. But there are other difficulties, which inhere in the subject itself. To test a variety for any purpose, it is necessary to actually grow it and use it for that purpose. The chief end of most varieties is for the market, but the experiment station cannot grow varieties for commercial market. One crate or even one shipment does not test the shipping qualities of a variety, for these qualities vary with the season, the weather, the methods of transportation, and with the different pickings of the same variety; and it is therefore impossible to give any adequate test to twenty or thirty or even more varieties of any one fruit, let alone

the many kinds of fruits and other products with which the experimenter is supposed to deal. It is said that one can judge from the looks and behavior of a variety if it will be a good shipper, but I must remind my reader that this short-cut method of arriving at conclusions is one reason why so many disappointing varieties are introduced. And besides this, the variety may behave differently in different seasons, and in every various soil and treatment. The emphatic impression of this fact upon my mind was the only good result which came out of my first test of strawberries. Over forty varieties were grown, and I made the most conscientious attempt not only to make notes upon productiveness and behavior, but to personally eat every kind. I ate across the patch north and south, east and west, backwards and forwards. The results of the whole test were duly published; whereupon a neighbor three miles away said it might all be very well, but the varieties did not behave that way with him!

What the farmer wants to know is the value of the variety upon his place, not upon the experiment station farm, and he is the only person who can find it out. To thoroughly test a variety is to introduce it. When it is once introduced, the general consensus of opinion of men who actually grow it for the purposes for which it is desired, forms the best and the only criterion of its value. Even then, there may be farms, as every horticulturist knows, upon which a variety that is generally condemned may succeed; and the variety is then not a failure. Now, the discovering of this consensus of opinion, and publishing it, is just the work which the experiment station can perform when it desires to spread information of varieties. The standard of actual sales in commercial plantations is the only correct one for market fruits and this is to be had only from farmers themselves. A series of tabulated reports, from growers who are capable judges of particular fruits, is capable of giving reliable information of varieties. If, in connection with such reports, the experimenter can add his own experience, very much will be gained; and he often has the great advantage of receiving varieties before they are put upon the general market. And the greater use he makes of the reports of others, the more valuable does his own variety patch become as a means of study and comparison.

I have said this much as a general answer to many inquiries from New York fruit growers asking for lists of fruits which they should plant, and as an explanation to originators or intro-



ducers of our attitude towards their novelties. We are always glad to receive new varieties for growing in the University gardens, and to make a written report of their behavior from time to time, but we have steadily refused to publish tests of them, except when

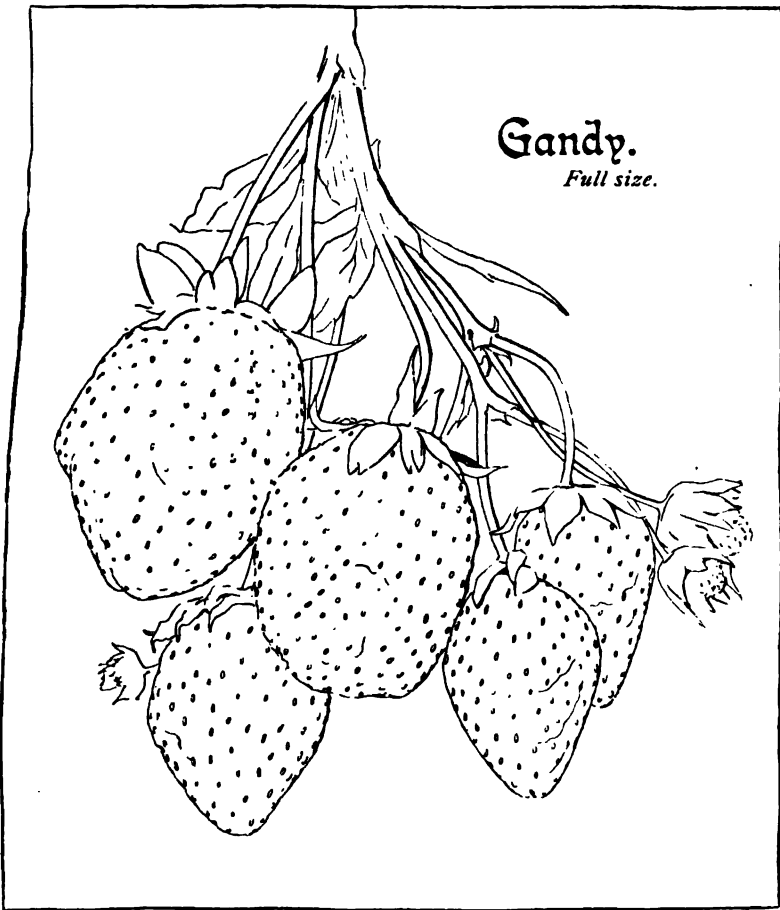
monographing certain groups of plants into which they naturally fall ; and even then we have often derived much more information from the commercial plantations in various parts of the state than we have from our own orchards and gardens. I like to think of New York state as one great experiment station, from which we should try to catch up the lessons as they pass.

Just as the last strawberry season was closing and while the subject was fresh in the minds of the growers, I applied to over one-hundred strawberry raisers for information concerning varieties. Most of these men are rather large growers, and the list includes, I think, most of the leading commercial strawberry growers in the western part of the state. These replies are tabulated below, and they afford an accurate measure of the standing of the different strawberries amongst men most capable of judging them. More accurate conclusions could have been drawn concerning the distribution of varieties and their special adaptabilities if the number of respondents had been greater ; but the replies are sufficient, I think, to enable the person who intends to plant strawberries in western New York to arrive at safe conclusions concerning varieties.

It is interesting to observe the great variety of soils upon which the respondents grow strawberries. Every type of farm soil is mentioned in the replies. Yet there is a very great preponderance in favor of the loamy and light soils. Of those growers who have an acre or more of berries, forty mention some variety of sand, or sandy or gravelly loam ; while only sixteen mention clay in any form, and the greater number of these specify a clay loam, indicating that the original clay foundation has been well broken up by tillage and fertilizing. The aspect and comparative elevation of strawberry land are probably more important considerations in this state than the mere character of soil, for these features bear a vital relation to soil moisture and to frosts. The replies of the commercial growers certainly indicate that a great variety of soils can be used with entire success in the cultivation of the strawberry ; but it is safe to infer that tillage and other treatments are important factors in rendering many of them utilizable.

NOTE —The Bryant strawberry mentioned by respondent No. 47, is sometimes known as the Wayne County Eureka, but it differs much from the true

Eureka, particularly in being a perfect-flowered variety. The berry is very firm, slightly angular, ripening just after Crescent. I have named it for L. J. Bryant, a skillful gardener of Newark, who writes as follows concerning its origin: "It is a chance seedling which came up on our grounds where we had an old plantation of Sharpless and Crescent; as it shows in many ways the leading traits of both those varieties, we call it a cross of Crescent and Sharpless. It originated in 1885 and for the last five or six years we have planted it quite extensively on all kinds of soils. For vigor, freedom from disease, productiveness, high color, firmness for shipping, and a berry for all purposes, it leads anything I have found."



STRAWBERRY REPORTS.

Grower.	County.	Soil.	Area.	Earliest variety.	Latest variety.	Most productive variety.	Best shipper.	Best home berry.	Best all around strawberry.
1	Erie	Black Sand	2½ acres	Michel	Parker Earle	Crescent	Crescent	Crescent	Crescent
2	"	Slate Gravel	1 "	Michel	Haverland	Haverland	Haverland	Haverland	Haverland
3	"	Sandy Loam	5 "	Michel	Parker Earle	Haverland	Lovett	Gandy	Haverland
4	"	"	"	Michel	Parker Earle	Crescent	Crescent and Wilson	Crescent and Parker Earle	Crescent
5	"	"	3 "	Michel	Captain Jack	Crescent	Wilson	Crescent	Crescent
6	"	"	4 "	Michel	Parker Earle	Crescent	Wilson	Crescent	Crescent
7	"	Gravelly Loam	1½ "	Beder Wood	or Timbrell	Haverland	Warfield	Haverland	Haverland
8	"	Sandy Loam and Slate Gravel	7 "	Michel	Wilson	Crescent	Crescent	Crescent	Crescent
9	"	Gravelly Loam	6 rows 110 ft. long	—	Parker Earle	Parker Earle	—	Parker Earle	Parker Earle
10	Niagara	Sandy Loam	—	Wilson	Crescent	Wilson	Wilson	Crescent and Wilson	Wilson
11	"	"	—	Crescent	Mt. Vernon	Crescent	Wilson	Mt. Vernon	Crescent
12	"	Gravel and Clay	1 acre	Crescent and Michel	Parker Earle	Crescent and Wilson	Wilson	—	Wilson
13	"	Gravelly Loam	—	Sharpless	Sharpless	Sharpless	Wilson	Wilson	Wilson
14	Orleans	Sandy and Clay Loam	¼ acre	Jessie	Bubach	Parker Earle	—	Wilson	—
15	"	Sand and Clay	¼ "	Dayton and Wilson	Parker Earle	Parker Earle	Wilson	Dayton and Wilson	Wilson
16	"	Sandy Loam	1 "	Michel	Gandy and Timbrell	Crescent	Gipsy and Warfield	Wilson	Wilson and Bubach
17	"	Sandy	5 "	Michel	Gandy	Crescent	Gandy	Jessie Bubach	Warfield
18	"	Clay Loam	½ "	Michel	Gandy	Haverland	Warfield	Dew and Jessie	Dew
	"	Clay	¼ "	Crescent or Warfield	Mt. Vernon	Wilson	Wilson	Cumberland	Wilson

19	Orleans	Clay Loam	5 sq. rods	Warfield	Jessie	Warfield Parker Earle, Haverland	Manchester and Wilson	Jessie	Warfield
20	Genesee	Sandy Loam	2 acres	Bubach	Manchester	Parker Earle, Haverland	Manchester and Wilson	Bubach	Warfield
21	Wyoming	Dark Loam	—	Michel	Gandy	Sharpless	—	Sharpless	Parker Earle
22	Allegany	Hard Stony	60 rods	Crescent	Mt. Vernon	Crescent	—	Crescent	Crescent
23	Livingston	Sandy Loam	1/2 acre	Michel	Timbrell	Parker Earle	Miner	Parker Earle	Crescent
24	"	Dark Loam	—	Michel	Gandy	Sharpless	—	Sharpless	Sharpless
25	"	Gravelly Clay Loam	1/4 acre	Bubach	Wilson	Wilson	Wilson	Bubach	—
26	"	Creek Wash	3 "	Michel	—	Crescent	—	Crescent	—
27	Monroe	Sandy	1 "	Wilson	Bubach	Wilson	Wilson	Crescent	Wilson
28	"	Sandy Loam	4 "	Michel	Manchester	Warfield	Wilson	Jessie	Warfield
29	"	"	1 rows 15 rods long	Crescent	Gandy	Bubach	—	Bubach	—
30	"	"	1/4 acre	Michel	Dew	Wilson	Wilson	Michel	Wilson
31	"	"	5 rows 12 rods long	Crescent	Bidwell	Ridwell	—	—	—
32	"	Sandy	1 acre	Wilson	Gandy	Wilson	—	Wilson	Wilson
33	"	Yellow Loam	2 "	Crescent	Wilson	Crescent	Wilson	—	—
34	"	Light Sandy	1 "	Crescent	Wilson	Crescent	Wilson	Wilson	Wilson
35	"	—	—	Michel	Gandy and Timbrell	Haverland	—	Sharpless	Burbach
36	"	Medium Light Sand	1/2 acre	—	—	—	—	—	Wilson
37	"	Sand and Gravel	1 "	Hoffman	Wilson	Wilson	Wilson	Bubach	Wilson
38	"	Sandy Loam	8 "	Michel	Eureka	Greenville	Wilson	Greenville,	Greenville
39	"	Sand and Gravel	1/4 "	Wilson	—	Wilson	Wilson	Bader Wood	Wilson
40	"	Black Loam	1 "	Wilson	Bubach	Wilson	Wilson	Wilson	Wilson
41	"	Gravel and Chestnut Loam	4 "	Wilson	—	Wilson	Wilson	Jessie	Wilson
42	"	Gravel and Sandy loam	1 "	Gipsy fertilized	Warfield	—	Wilson	Gipsy	Gipsy and
43	"	Sandy	1 "	Scrawler	Jessie	Scrawler	Scrawler	Jessie	Scrawler
44	Wayne	Muck	20 rods	Wilson	Jessie	Wilson	Wilson	Jessie	Jessie
45	"	Sandy	1/4 acre	Warfield	Mammoth	Warfield	Wilson	Warfield	Wilson

STRAWBERRY REPORTS.—CONTINUED

Grower	County.	Soil.	Area.	Harliest variety.	Latest variety.	Most productive variety.	Best shipper.	Best home berry.	Best all around strawberry.
46	Wayne	{ Sandy Loam	3/4 acres	Crescent and	—	Wilson	—	—	—
47	"	{ Heavy Loam	"	Wilson	—	Warfield	—	—	—
48	"	{ and Light Sand,	3	Crystal City and	Gandy	Warfield	Bryant and	Crescent	Bryant
		{ Sandy	2	Michel	Gandy	Warfield	Gandy	Bubach	Warfield
49	"	{ Sandy, Gravelly	6 to 8 "	Michel	Shuckless,	Warfield,	Haverland,	Shuckless,	Haverland
		{ and Clay Loam			Gandy and	Crescent and	Michel and	Pineapple	
50	"	{ " "			Manchester	Haverland	Warfield	Lovett and	
51	"	{ Sandy Loam	"	Michel	Miner	Lovett, Mi-	Warfield	Miner	—
52	"	{ Heavy " "	1/2	Crescent	Jersey Queen	Bubach	Warfield	—	Bubach
53	"	{ Clay " "	1/2	Crescent	Wilson	Crescent	Warfield	—	—
		{ " "		Jessie	Wilson	Wilson	Wilson	Jessie	Wilson
54	Ontario	{ Gravelly Loam	1/3	Bubach	Gandy	Bubach	Warfield	Bubach and	Warfield
55	"	{ " "			New Domin-				
56	"	{ Clay Loam		Crescent	ion	Cumberland	—	Cumberland	—
57	"	{ Sandy	1	Bidwell	Parker Earle	Haverland	—	Jessie	Crescent
58	"	{ Sandy Loam	2	Michel	Burt	Crescent	Burt	Crescent	Crescent
59	"	{ Gravelly Loam		Wilson	Sharpless	Sharpless	—	Warfield	—
		{ Light Sand	1-5	Chas. Downing	Parker Earle	Bubach	—	Bubach	Bubach
60	"	{ " "		VanDeman and			—		
		{ Clay Loam	3	Michel	Jersey Queen	Crescent	Wilson	Wilson	Jessie
61	"	{ " "					Princess and	Princess and	Princess
62	"	{ Clay		Crescent	Cumberland	James Vick	—	Cumberland	—
63	"	{ Stiff Clay	1 1/2	Michel	Sharpless	Eureka	—	Eureka	Eureka
64	"	{ Clay Loam			Eureka	Warfield	Wilson	Gillespie	Parker Earle
		{ " "			Yale		Yale		
65	Yates	{ Yellow Clay	1	Crescent	Sharpless	Crescent	Giant of the	Sharpless	Crescent
		{ Loam					West		

66	"	Sandy Loam	2	acres	Wilson	Sharpless	Wilson	Sharpless	Wilson
67	"	Clay	1	"	Michel	Crescent	Crescent	Sharpless	Sharpless
68	"	Sandy Clay	—	—	May King	Haverland	Haverland	Bubach and Haverland	Bubach
69	"	" Loam	1	"	Bidwell	Enhance	Enhance	Cumberland	Cumberland
70	Cayuga	Clay	—	—	Crescent	Gandy	Crescent	and Enhance	Parker Earle
71	"	Strong Loam	1	"	Pacific or Crescent	Gandy	Crescent	Parker Earle	Greenville
72	Tompkins	Clay	1	"	Michel	Gandy	Crescent	Crescent	Crescent
73	"	Gravelly Clay	1 1/4	"	Michel	Eureka	Burt	Burt and Haverland	Burt and Haverland
74	"	Stony Loam	1	"	Michel	Gandy	Crescent	Crescent	Crescent
75	Onondaga	Gravelly Loam	3	—	Michel	Parker Earle	Parker Earle	Parker Earle	—
76	"	Sandy	7	"	Crescent	Burt	Crescent	Gipsy	Gipsy
77	"	Heavy Gravel	2	"	Michel	Manchester	Crescent	Captain Jack	Captain Jack
78	Oneida	Gravelly Loam	2	"	Michel	Parker Earle	Haverland	Parker Earle	Crescent
79	"	Gravel	3 1/2	"	Michel	Haverland	Crescent	Haverland	Haverland
80	Herkimer	Clay Loam, Sand Loam, Gravel	20	"	Michel	Gandy	Crescent	Gandy	Bubach
81	"	and Clay	6	"	Warfield	Bubach	Warfield	Warfield	Warfield
82	"	Sandy Loam	2	"	Crescent	Jessie	Warfield	Warfield	Warfield
83	Montg'ry	BlackLoamClay	1/2	"	Michel	James Vick	Warfield	Warfield	Warfield
84	Saratoga	Clay Loam	4 rods	"	Princess	and Burt	Sharpless	Sharpless	—
85	Jefferson	"	2	acres	Michel	Gandy	Crescent	Warfield	Warfield
86	"	Sandy Loam	1	"	Michel	Burt	Crescent	Warfield or Parker Earle	Crescent
87	Orange	Heavy Clay	1	"	Orange Co.	Parker Earle	Warfield	Warfield	Enhance
88	Oswego	and Slate	1	"	Bubach	Timbrell	Enhance	Timbrell	Parker Earle
89	"	Gravel & Loam	3/4	"	Beder Wood	Parker Earle	Parker Earle	Bubach	Burt
90	"	Clay Loam	2	"	Michel	Burt	Warfield	Warfield	Parker Earle
		Stony	5	"		Parker Earle	Parker Earle	Parker Earle	Parker Earle

STRAWBERRY REPORTS.—*Concluded.*

1914 No.	County.	Soil.	Area.	Earliest variety.	Latest variety.	Most produc- tive variety.	Best shipper.	Best home berry.	Best all around strawberry.
91	Oswego	Gravel & Loam	10 acres	Michel	Parker Earle	Haverland	Parker Earle	Haverland	Haverland
92	"	Sand and Gravelly Loam	2 "	Beder Wood	Parker Earle	Warfield	Champion	Haverland	Haverland
93	"	Gravelly Loam	1/4 "	Wilson	Atlantic	Burt	and Wilson	Beder Wood	Bubach
94	"	Clay	3/4 "	Lovett Early	Gandy	Warfield	Atlantic	Burt	Atlantic
95	"	Gravelly Loam	1/2 "	Michel	Parker Earle	Parker Earle	Warfield	Warfield	Warfield
96	"	Clay Loam and Gravel	1 1/4 "	Michel	Gandy	Eclipse, Bar- ton and Beder Wood	Parker Earle	Parker Earle	Parker Earle
97	"	Clay and Sandy Loam	4 "	Michel	Gandy	Parker Earle	Gandy	Haverland, Middlefield	Haverland
98	"	Sandy Loam	9 "	Mt. Vernon	Parker Earle	Parker Earle	Parker Earle	Greenville	Bubach
99	"	Clay Loam and Black Sandy	2 "	Haverland	Parker Earle	Crescent	Atlantic	Sharpless	Haverland
100	"	Stony	1/3 "	Bubach	Haverland	Burt and Bubach	Burt	Haverland	Haverland
101	"	Sandy Loam	1 "	Crescent	Parker Earle	Parker Earle	Wilson	Bubach	Bubach
102	"	Mud and Gravel	2 "	Michel	Eureka	Bubach	Parker Earle	Parker Earle	Parker Earle
103	"	Clay and Stony	1 "	Crescent	Atlantic	Crescent and Burt	Burt	Michel	Bubach
104	"	Yellow Loam	5 1/2 "	Beder Wood	Parker Earle	Parker Earle	Atlantic	Atlantic	Atlantic
105	"	Clay Loam	2 "	Michel	Parker Earle	—	Parker Earle,	Bubach	Bubach
106	"	Gravel	1/2 "	Beder Wood	Atlantic	Bubach	Edgar Queen	Jersey Queen	—
107	"	Sandy and Gravelly Loam	2 "	Haverland	Parker Earle	Haverland	Atlantic	Belmont	Atlantic
108	"	Gravelly Loam	3/4 "	Wilson	Atlantic	Wilson	—	Haverland,	Haverland
109	"	Clay Loam	1/4 "	Wilson	Burt	Wilson	Atlantic and	Parker Earle	Haverland
110	"	Sandy Loam	1 "	—	Sharpless	Parker Earle	Wilson	Bubach	Wilson
							Bubach	Wilson	Wilson
							Sharpless	Crescent	Crescent

The most striking feature of these replies is the various character of them. Here are 52 varieties recommended for one or another purpose by 110 persons, and there are scarcely two persons in the list who recommended the same varieties for the various uses! This is conclusive evidence that a test ever so well made at Ithaca, would be of very little use in the various parts of the state; for the grower would still need to find out which ones of the varieties which we might recommend would be valuable at his own place, and as likely as not he would find distinct merits in varieties which we should condemn. The replies show very distinctly how great are the differences in the acknowledged merits of varieties in different places. Take, for instance, the six most popular varieties of the lot—Wilson, Crescent, Parker Earle, Warfield, Bubach, Michel—and notice the different estimates placed upon them in various sections. In Oswego county, where a late berry is desired, Parker Earle far outranks all other varieties. In Monroe county, Wilson is mentioned seven times where the other leading sorts are mentioned once, and Parker Earle is not mentioned at all! In Erie county, Crescent outranks all others. Let us see how many times these six varieties are mentioned in each of six leading strawberry counties of western New York:

Erie County (9 reports)—

Crescent,	-	-	Mentioned	18	times.
Parker Earle,	-	-	"	7	"
Wilson,	-	-	"	7	"
Michel,	-	-	"	6	"
Warfield,	-	-	"	1	"
Bubach,	-	-	"	0	"

Orleans County (6 reports)—

Wilson,	-	-	Mentioned	8	times.
Warfield,	-	-	"	7	"
Crescent,	-	-	"	3	"
Michel,	-	-	"	3	"
Parker Earle,	-	-	"	2	"
Bubach,	-	-	"	1	"

Monroe County (17 reports)—

Wilson,	-	-	Mentioned	41	times.
Bubach,	-	-	"	6	"
Crescent,	-	-	"	6	"
Michel,	-	-	"	5	"
Warfield,	-	-	"	4	"
Parker Earle,	-	-	"	0	"

Wayne County (10 reports)—

Wilson,	-	-	Mentioned	15	"
Warfield,	-	-	"	9	"
Crescent,	-	-	"	6	"
Michel,	-	-	"	5	"
Bubach,	-	-	"	3	"
Parker Earle,	-	-	"	0	"

Ontario County (11 reports)—

Crescent,	-	-	Mentioned	8	times
Bubach,	-	-	"	6	"
Warfield,	-	-	"	5	"
Wilson,	-	-	"	4	"
Michel,	-	-	"	3	"
Parker Earle,	-	-	"	3	"

Oswego County (23 reports)—

Parker Earle,	-	-	Mentioned	34	times.
Bubach,	-	-	"	16	"
Wilson,	-	-	"	13	"
Michel,	-	-	"	8	"
Warfield,	-	-	"	8	"
Crescent,	-	-	"	6	"

Wilson is the most popular variety in three counties, Crescent in two, and Parker Earle in one; although it should be said that where there are few reports and where one variety leads the others by only a small majority, definite conclusions cannot be safely drawn. But certainly there is no escape from the conviction that Wilson is still the leading berry in Monroe and Wayne counties, as Parker Earle is in Oswego county. It is interesting to note that Bubach occupies the last or next to the last place in three instances, but rises to the second place in the three other counties;

and Crescent, which is prominent in other reports, sinks to the last place in Oswego county. Parker Earle, which clearly leads in the minds of the Oswego growers, occupies next to the last place in Orleans, and is not even mentioned in Monroe or Wayne. It is singular that Michel occupies essentially the same position in all the counties, but this is because it really has no close competitors amongst the early berries.

This diversity of opinion is nowhere better shown than in the recommendations of berries for home use, a circumstance which arises from the fact that every person establishes his own standard of excellence. Thus, whilst there are 24 varieties named for shipping, there are 31 varieties recommended for home use, as follows :

Best Home Berries.

Bubach, 12 votes.	Gillespie, 1 vote.
Crescent, 12 votes.	Gipsy, 1 vote.
Jessie, 9 votes,	Jersey Queen, 1 vote.
Wilson, 9 votes.	Timbrell, 1 vote.
Sharpless, 8 votes,	Bubach and Haverland, 1 vote.
Warfield, 8 votes.	Bubach and Warfield, 1 vote.
Parker Earle, 7 votes.	Crescent and Mt. Vernon, 1 vote.
Haverland, 5 votes.	Crescent and Parker Earle, 1 vote.
Michel, 4 votes.	Cumberland and Enhance, 1 vote.
Cumberland, 2 votes.	Dayton and Wilson, 1 vote.
Greenville, 2 votes.	Dew and Jessie, 1 vote.
Atlantic, 1 vote.	Greenville & Beder Wood, 1 vote.
Belmont, 1 vote.	Haverland & Middlefield, 1 vote.
Beder Wood, 1 vote.	Haverland & Parker Earle, 1 vote.
Burt, 1 vote.	Lovett and Miner, 1 vote.
Eureka, 1 vote.	Princess and Cumberland, 1 vote.
Gandy, 1 vote.	Shuckless and Pineapple, 1 vote.
Thirty-one varieties ; 101 votes.	

The Best Shippers.

Wilson, 29,	Scrawler, 1.
Parker Earle, 10.	Timbrell, 1.
Warfield, 8.	Yale, 1.
Burt, 5.	Atlantic and Wilson, 1.

Atlantic, 4.	Bryant and Gandy, 1.
Crescent, 3.	Burt and Haverland, 1.
Gandy, 4.	Champion and Wilson, 1.
Haverland, 2.	Crescent and Wilson, 1.
Bubach, 1.	Cumberland and Enhance, 1.
Captain Jack, 1.	Gipsy and Warfield, 1.
Crawford, 1.	Haverland, Michel & Warfield, 1.
Giant of the West, 1.	Manchester and Wilson, 1.
Gipsy, 1.	Parker Earle and Edgar Queen, 1.
Lovett, 1.	Warfield or Parker Earle, 1.
Miner, 1.	

Twenty-four varieties ; 85 replies.

The Most Productive Varieties.

Crescent, 24 votes.	James Vick, 1 vote.
Wilson, 15 votes.	Scrawler, 1 vote.
Warfield, 14 votes.	Burt and Haverland, 1 vote.
Haverland, 11 votes.	Crescent and Burt, 1 vote.
Parker Earle, 11 votes.	Crescent and Wilson, 1 vote.
Bubach, 7 votes.	Haverland, Eclipse, Barton, and Beder Wood, 1 vote.
Sharpless, 4 votes.	Lovett, Miner and Wilson, 1 vote.
Burt, 2 votes.	Parker Earle and Bubach, 1 vote.
Enhance, 2 votes.	Parker Earle & Haverland, 1 vote.
Bidwell, 2 votes.	Sharpless and Crescent, 1 vote.
Cumberland, 1 vote.	Warfield, Crescent and Haver- land, 1 vote.
Eureka, 1 vote.	
Greenville, 1 vote.	

Twenty varieties ; 106 votes.

The Early and Late Berries.

Earliest variety.	With persons.	Latest variety.	With persons.
Michel,	39	Parker Earle,	22
Crescent,	18	Gandy,	16
Wilson,	12	Wilson,	8
Bubach,	6	Burt,	5

Beder Wood,	4	Sharpless,	5
Warfield,	3	Atlantic,	4
Bidwell,	2	Bubach,	4
Jessie,	2	Eureka,	4
Chas. Downing,	1	Haverland,	4
Haverland,	1	Jessie,	4
Hoffman,	1	Manchester,	3
Lovett,	1	Mt. Vernon,	3
May King,	1	Crescent,	2
Mt. Vernon,	1	Jersey Queen,	2
Orange Co.,	1	Timbrell,	2
Princess,	1	Bidwell,	1
Scrawler,	1	Captain Jack,	1
Sharpless,	1	Cumberland,	1
Beder Wood and Haverland,	1	Dew,	1
Crescent and Michel,	2	Enhance,	1
Crescent or Warfield,	1	Miner,	1
Crescent and Wilson,	1	Monmouth,	1
Crystal City and Michel,	1	New Dominion,	1
Dayton and Wilson,	1	Warfield,	1
Gipsy fert. with Wilson,	1	Yale,	1
Pacific or Crescent,	1	Burt and Haverland,	1
VanDeman and Michel,	1	James Vick and Burt,	1
Eighteen varieties; 108 persons.		Parker Earle or Timbrell,	1
		Shuckless, Gandy and Man- chester,	1
		Twenty-five varieties; 104 persons.	

Best all around Strawberry.

Wilson, 20 votes.

Crescent, 16 votes,

Bubach, 10 votes.

Haverland, 10 votes.

Warfield, 10 votes.

Parker Earle, 7 votes.

Atlantic, 3 votes.

Sharpless, 2 votes.

Jessie, 2 votes.

Bryant, 1 vote.

Burt, 1 vote.

Captain Jack, 1 vote.

Cumberland, 1 vote.

Dew, 1 vote.

Enhance, 1 vote.

Eureka, 1 vote.

Gipsy, 1 vote.

Greenville, 1 vote.

Princess, 1 vote.

Scrawler, 1 vote.

Burt and
Haverland, } 1 vote.

Gipsy and
Wilson, } 1 vote.

Wilson and
Bubach, } 1 vote.

Twenty varieties ; 94 votes.

Taken altogether, the Wilson is evidently still the most popular strawberry in western New York. It is strange that, amongst all the new varieties, there are none which are able to supplant it. Its great enemy is the leaf-blight or rust, and were it not for this the variety would certainly far outclass all others for general market purposes. I am not sure, however, that the variety which we now grow as the Wilson is identical with the original stock. It would be strange if it were so. In hundreds of generations of propagations, many of the variations induced by soil and methods

of cultivation are likely to be perpetuated. Careful propagators select young plants from those portions of the plantation which produce what they consider to be the ideal berry, but as no two propagators have the same ideal berry in mind, there must arise a series of divergences in the type. It is certain that there are

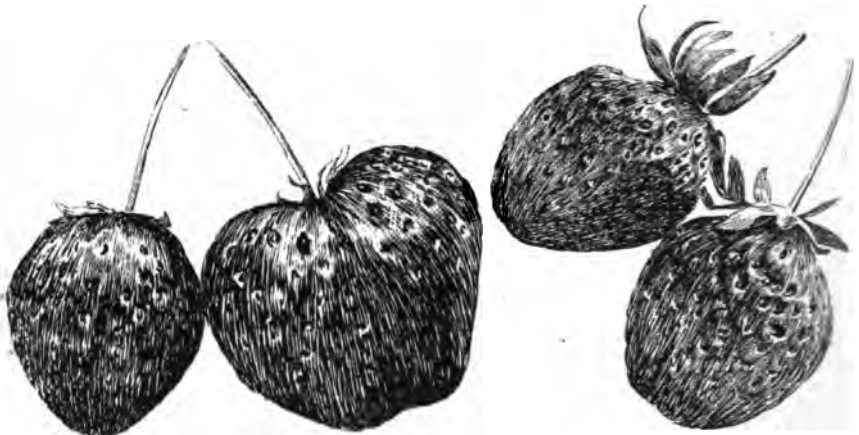


different strains of Wilson in cultivation, as there are different strains of the Crawford peach ; and it is no doubt this very diversity in the variety which adapts it so readily to many soils and uses. I often wonder if the original type of the Wilson, were it to be again introduced, would find so much favor as its modern progeny does.

Crescent, I imagine, will not hold its own so long as the Wilson has. Michel and Parker Earle, amongst the newer kinds, have distinct merits, one for its earliness and the other for its lateness and generally desirable qualities. Sharpless is passing out, whilst Bubach, Haverland and Warfield are holding their own.

II. LEAF-BLIGHT.

Forty-two of the 110 persons are troubled with the blight or rust of strawberry foliage. This shows that the trouble is rather serious. It is not uniformly spread over the state, however. Most of the replies in Monroe, Ontario and Wayne counties say



Bubach.

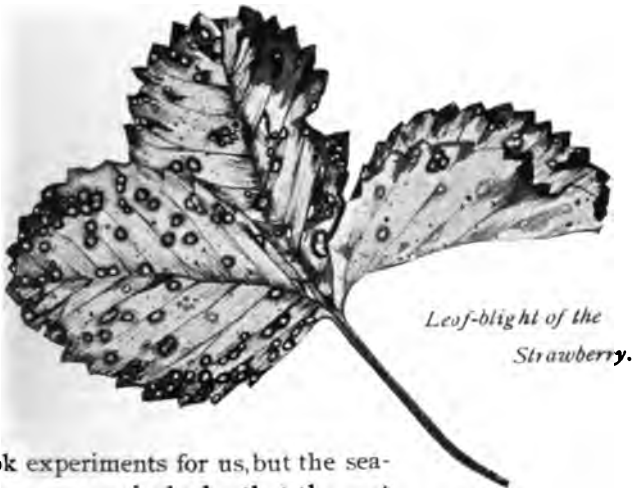
Warfield.

that the rust is not prevalent. In other places, it seems to have almost driven out the Wilson.

This blight is a fungus (*Sphaerella Fragariæ*), the life history of which is discussed in Bulletin XIV. of this station (December, 1889). The spots showing fungous attack are brownish at first, but afterwards become dry and whitish, with a circle of red; and finally the entire leaf assumes a red-spotted or red-discolored appearance. The blight does its worst mischief in the summer, after the fruit is off, by preventing growth and lessening the crop of the following year. The disease usually begins to attack the leaves before the fruit is off, however, and in some cases even

earlier. There are two methods of dealing with this disease in this state,—discarding susceptible varieties, and plowing up the patch after the first crop is off. These means are very effective when they are systematically pursued. There is a general and growing tendency to fruit the strawberry patch but one year, and there are strong reasons in favor of it aside from the desire to check the blight.

It has been proved by Professor Garman, of Kentucky, and others, that this leaf-blight can be subdued by fungicides, but it remained to make a practical test of the operation in strawberry fields in this state. Mr. Walter F. Taber, of Poughkeepsie, un-



*Leaf-blight of the
Strawberry.*

dertook experiments for us, but the season was so excessively dry that the rust did not spread, and he obtained no results. I also made a test upon the farm of A. L. Stickney, North Collins, Erie Co. The berries were Crescent and Lovett, planted upon light sandy or gravelly soil, and the patch had given one crop. Parts of the plantation were heavily sprayed on July 7, with Bordeaux mixture (6 lbs. sulphate copper, 4 lbs. lime, 40 gallons water). A prolonged drought followed, and the plantation was much neglected. A second spraying was given July 23, but the weeds were so numerous that the application could not be properly made. The disease did not spread rapidly because of the dryness. On

account of the drought and the weedy condition of the patch, no further treatment was given. Despite these disadvantages, when the final visit was made to the plantation October 13, it was found that there was nearly twice as much disease upon the untreated rows as upon the sprayed ones, a conclusion at which Mr. Stickney also arrived. There was some rust on the sprayed rows, but the spots upon the leaves were small and they had not interfered seriously with the welfare of the plants, for the rows were dark and vigorous in color. The unsprayed rows, however, were distinctly lighter in cast, and the leaves were more profusely spotted. It should be borne in mind that it had been nearly three months since the last spray was applied, and even then the conditions were the very worst for the success of the experiment.

Mr. H. L. Barton, of Mexico, Oswego county, has made a similar experiment, his account of which follows :

The strawberry leaf-blight first appeared with me the middle of last June upon Phillip's Seedling. About July, the Gillespie and Greenville were affected. About Aug. 1st I applied with brush-broom Bordeaux mixture (5 lbs. copper sulphate, 4 lbs. lime to 40 gallons water, then reducing with water to one-half the strength). In some ten or twelve days the leaves assumed a healthier appearance, new leaves showing. In a few days the blight again appeared worse than before. The Gillespie and Greenville were especially attacked by the disease. About the middle of September the mixture was again applied. Another application, with quicker results, was made about October 15. The blight was then less active and the vines were growing faster; the weather was cooler and not as favorable for the development of the disease. It seems to thrive in warm sultry weather. These three varieties are the only ones affected in some eighty kinds in cultivation. At present date the blight is scarcely perceptible because of the spray, the leaves having assumed a dark green, healthy appearance.

H. L. Barton

SUMMARY.

The leading variety of strawberry in western New York, for general cultivation, if one may judge from the replies of 110 growers, is the Wilson.

The second place seems to be given to Crescent. This is followed closely by Bubach, Haverland, Warfield and Parker Earle.

Each important strawberry center has its own list of favorites. Thus, while Wilson and Crescent are, in general, the most popular varieties, in Oswego county the leading berries seem to be Parker Earle and Bubach.

The most popular berry for earliness is Michel. Its closest second is Crescent, although this receives less than half the votes which the Michel does.

Parker Earle and Gandy contend for popularity as late berries, the former being more strongly endorsed in Oswego county. All things considered, Parker Earle is probably our best late berry, which has been well tested. There are more candidates amongst the late sorts than amongst the early ones.

The most productive variety is the Crescent, although the Parker Earle occupies this place in Oswego county and it is closely followed there by Haverland and Bubach. In general, Wilson and Warfield occupy second and third places for productivity.

The best shippers are Wilson, Parker Earle and Warfield, with the Wilson (save in Oswego county) being far in the lead.

There is no unanimity of opinion as to the best berry for home use. One hundred and one people mention 31 varieties for this honor. The four kinds receiving the most votes are Bubach, Crescent, Jessie, Wilson.

Altogether, 52 varieties are recommended for some purpose, of which less than a dozen are very prominent: Wilson, Crescent, Bubach, Haverland, Parker Earle, Warfield, Michel, Gandy, Jessie.

The blight or rust of strawberry leaves is the work of a parasitic fungus. This disease causes the foliage to become spotted and red, and the plant suffers. The chief injury is commonly wrought in summer.

This disease is partial to some varieties, and the first step towards its control is to discard such susceptible kinds.

If one sets healthy plants upon clean land, there is generally little trouble with the blight until the first crop is removed. It has come to be a common and excellent practice, therefore, to fruit the patch but one year.

The disease is also readily controlled by thorough sprayings with Bordeaux mixture. If the attack has been pronounced the preceding year, the first spraying should probably be given in spring before the flowers appear. Ordinarily, the first treatment may be given as soon as the berries are picked, and the applications should be repeated two or three or more times, as occasion seems to demand.

L. H. BAILEY.



Set in a hurry.



Too high.



Good !

630.679
N7
C8e
Bulletin 80.

December

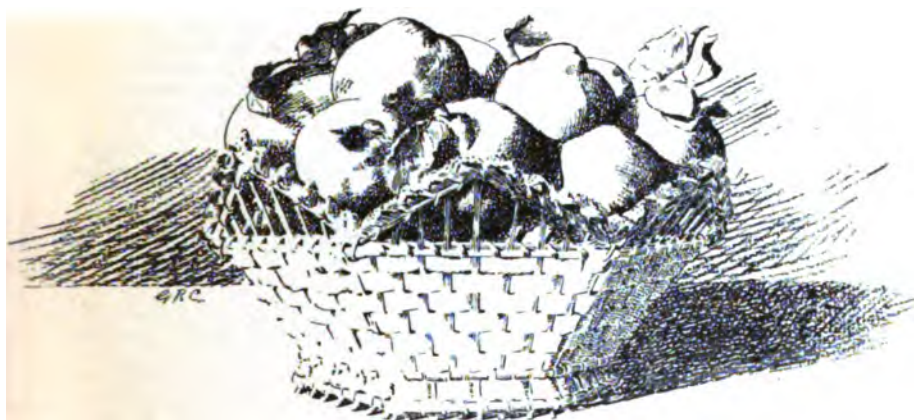


Cornell University Agricultural Experiment Station.

HORTICULTURAL DIVISION.

THE QUINCE

IN WESTERN NEW YORK.



By L. H. BAILEY.

PUBLISHED BY THE UNIVERSITY,
ITHACA, N. Y.
1894.

ORGANIZATION.

BOARD OF CONTROL: THE TRUSTEES OF THE UNIVERSITY.

STATION COUNCIL.

President, JACOB GOULD SCHURMAN.

Hon. A. D. WHITE,	-	-	-	-	Trustee of the University.
Hon. JOHN B. DUTCHER,	-	-	-	-	President State Agricultural Society.
Professor I. P. ROBERTS,	-	-	-	-	Agriculture.
Professor G. C. CALDWELL,	-	-	-	-	Chemistry.
Professor JAMES LAW,	-	-	-	-	Veterinary Science.
Professor A. N. PRENTISS,	-	-	-	-	Botany.
Professor J. H. COMSTOCK,	-	-	-	-	Entomology.
Professor L. H. BAILEY,	-	-	-	-	Horticulture.
Professor H. H. WING,	-	-	-	-	Dairy Husbandry.
Professor G. F. ATKINSON,	-	-	-	-	Cryptogamic Botany.

OFFICERS OF THE STATION.

I. P. ROBERTS,	-	-	-	-	Director.
E. L. WILLIAMS,	-	-	-	-	Treasurer.
H. W. SMITH,	-	-	-	-	Clerk.

ASSISTANTS.

M. V. SLINGERLAND,	-	-	-	-	Entomology.
GEO. C. WATSON,	-	-	-	-	Agriculture.
G. W. CAVANAUGH,	-	-	-	-	Chemistry.
E. G. LODGMAN,	-	-	-	-	Horticulture.
MICHAEL BARKER,	-	-	-	-	Horticulture.

Office of the Director, 20 Morrill Hall.

Those desiring this Bulletin sent to friends will please send us the names of the parties.

BULLETINS OF 1894.

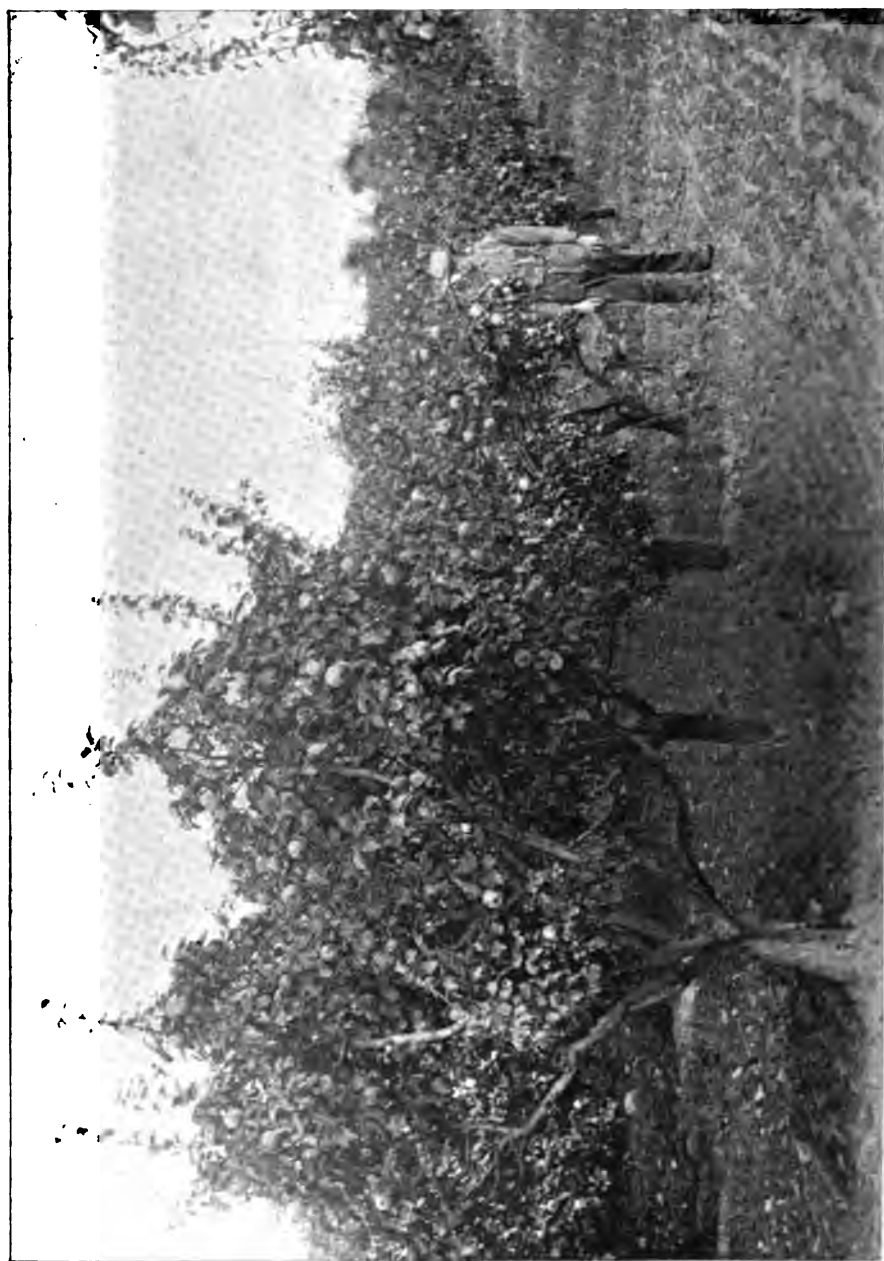
62. The Japanese Plums in North America.
63. Co-operative Test of Sugar Beets.
64. On Certain Grass-Eating Insects.
65. Tuberculosis in Relation to Animal Industry and Public Health.
66. Test of Cream Separators.
67. Some Recent Chinese Vegetables.
68. The Cultivated Poplars.
69. Hints on the Planting of Orchards.
70. The Native Dwarf Cherries.
71. Apricot Growing in Western New York.
72. The Cultivation of Orchards.
73. Leaf Curl and Plum Pockets.
74. Impressions of the Peach Industry in Western New York.
75. Peach Yellows.
76. Some Grape Troubles of Western New York.
77. The Grafting of Grapes.
78. The Cabbage Root Maggot, with notes on the Onion Maggot and Allied Insects.
79. Varieties and Leaf Blight of the Strawberry.
80. The Quince in Western New York.

CORNELL UNIVERSITY, ITHACA, Dec. 12, 1894.

THE HONORABLE COMMISSIONER OF AGRICULTURE, ALBANY.

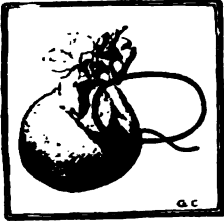
Sir: Quince growing is an important industry in the counties of Ontario, Monroe, Orleans and Niagara, and, to a less extent, in other parts of western New York. It is an interest which merits even greater attention than it receives, but there is very little literature upon the subject. I have therefore prepared a report upon its present condition in the Fifth Judicial Department, and upon certain investigations and experiments which we have made upon the quince. This report I submit as a bulletin in accordance with Section 87, Chapter 675, of the laws of 1894.

L. H. BAILEY.



1. - 1 model Quince Orchard, 18 years old, - fed, tilled, pruned and sprayed. (T. C. Maxwell & Bros., Geneva.)

THE QUINCE IN WESTERN NEW YORK.



QUINCES are more largely grown in western New York than elsewhere in the Union. The industry has grown up slowly and quietly, and has not attracted general attention, yet, in its way, it is one of the important agricultural interests of the state. Quince growing can never assume the proportions of other orchard industries, because of the limited demand for the fruit; and for this reason, also, the most careful attention must be given to marketing the crop and to reducing the injuries from a number of insect and fungous enemies. The crop has much in its favor; the trees are almost sure to bear nearly every year if they receive good care, and they are so small that spraying and thinning can be practiced with ease; there are no climatic difficulties to be overcome, and the fruit is not perishable. Added to this is the sentimental interest which attaches to the crop, for the quince tree, both in flower and fruit, is the handsomest fruit tree of temperate climates. The large flowers are borne upon the extremities of leafy shoots of the season, and they therefore appear after the leaves are grown and they clothe the whole exterior of the tree with a mantle of snowy whiteness at a time when the bloom of springtime already begins to wane. The golden fruits are all in sight, hanging upon the ends of the twigs, and they are more showy than oranges. It is easy to accept the supposition that the quince was the golden apple of the Hesperides of the early Greek writers.

The quince plantations of western New York range in size from a few square rods to several acres in extent; and the famous orchard of T. C. Maxwell and Bros. at Geneva, comprises about thirty acres. In general, the larger or more important plantations are well cared for; and yet there are certain directions in which the treatment of most of them might be improved. I have given

particular attention to the quince interests of the Fifth Judicial Department during the year, and have been able to draw certain conclusions from the study; and to this account I also add the results of three years' observation of varieties made upon our own grounds, and a sketch of experiments to control the leaf-blight.

Soils and fertilizers.—It is generally agreed, in this state, that the best soil for quinces is a heavy clay loam; that is, a clay soil which has become friable by good cultivation, fertilizing and draining. While the land should be well drained, it should nevertheless retain moisture more readily than is necessary for most other orchard fruits. Quinces often thrive upon light lands, but they are rarely as productive and long-lived as upon the heavier lands which I have described. According to Meech,* “in selecting soils, the first choice should be a strong loam, with enough sand in its composition to make it work easy. In a deep, strong soil the trees should not be expected to come into as early bearing as in the sandy soil, because the greater vigor of growth does not soon tend to the formation of fruit buds; but when they do bear they make up for any lost time by the abundance and quality of the fruit, and greater longevity, and immunity from disease.”

There has been no explicit field experimentation in this country, so far as I know, to discover the particular needs of the quince in matters of food; but the same general principles which apply to other tree fruits will no doubt apply to this, and these matters are discussed in Bulletin 72. It is now held that the controlling factors in orchard fertilizers should be potash and phosphoric acid rather than nitrogen; this last element induces growth, and the trees themselves may be supposed to register the needs in this direction. Trees which are yellow and stunted need either moisture or nitrogen, or both—providing they are not attacked by insect or fungous enemies—and these can be supplied by means of shallow tillage and nitrogenous or fibrous fertilizers, such as barn manures, green catch crops, or nitrogen in commercial form. If the trees are very dark green, with large leaves, and are making heavy growth at the expense of fruitfulness, either nitrogen or excessive cultivation should be withheld for a time; or the trees may

*Quince Culture, 34.

be severely headed-in, as explained farther on, although this last resort treats the symptoms rather than the fundamental difficulty. For potash, I should, in general, advise the best grade of muriate of potash, although wood ashes is excellent when the price is not too high for the quality of the material. Muriate of potash containing 50 per cent. of actual potash, may be applied at the rate of 200 to 300 pounds to the acre, sown broadcast and harrowed in. It may be applied in the fall or in earliest spring. Phosphorus may be obtained in bone compounds or dissolved South



2.—*The orchard that shifts for itself,—sod, borers and leaf-blight, but no quinces.*

Carolina rock, applied at the rate of 200 to 500 pounds to the acre. It is frequently said that common salt is an indispensable food for the highest production of the quince, but I am unable to find any reason for such opinion, and I do not know that any better results follow its application to quinces than to pears and other fruits. Salt is a conservator of moisture, and in this respect it may have especial value for quinces, inasmuch as these trees thrive best upon a rather moist soil.

The quince orchard should be kept in clean tillage. Orchards in sod generally give only indifferent results over a series of years, and they are especially liable to the ravages of borers and fungi. It is indisputable that the most economical means of securing and maintaining fertility and moisture is very frequent stirring of the surface soil. Fig. 2 shows an average condition of a soddy quince orchard during the past season; and one does not need to look twice to see that the harvesting of the crop does not impose serious difficulties!

The quince is a shallow rooted tree, and orchards which have been kept in sod cannot be plowed deeply. In many cases it is better to break up such orchards by thorough harrowing or cultivating in spring when the sod is soft, rather than by attempting to plow. Mulching quince trees is often recommended, but it is evident that this practice cannot be applied to large orchards; and, at best, it is a poor substitute for tillage, unless, possibly, in the case of old trees which have always been in sod and whose roots are very close to the surface. Borers and other difficulties may be expected to be more serious in mulched than in tilled orchards. Since quince orchards cannot be pastured, because the trees are too low, it follows that the only rational treatment is clean culture.

Propagation.—Upon light soils the quince is generally readily propagated by cuttings of the hard wood. These cuttings are taken in the fall or winter, the same as those of currants or grapes, and they are cut from 10 to 16 inches long. They should be stored for a couple of months or more in moist sand, moss or sawdust, or buried in a sandy place beyond reach of heavy frost, in order that they may callus, inasmuch as this process facilitates their growth when they are planted in the open ground in the spring. In heavy lands, cuttings are not often reliable, and resort is then had to mound-layering or "stooling," and to grafting on bits of apple roots, and to budding on quince stocks. These three methods are common in western New York. A "stool" is a plant which has been kept very low, the top being continually cut back, so that many suckers spring from the crown each year. A mound of earth about the suckers causes them to send out roots, so that they can be removed at the end of the first

or second year and they are then treated as independent plants. If apple roots are used, the quince cions are worked on them in the winter time, as in ordinary root grafting. The union with the apple is weak, but it is sufficient to afford support to the cion for a season or two, until roots strike from the quince itself. The plant is usually taken up the first fall and the apple root is cut off, otherwise troublesome apple suckers may arise. The quince cion should have thrown out roots by this time, and it is set in the nursery row again to shift for itself. Perhaps budding upon the quince itself is the method in most common use where propagation by cuttings is not practicable. The stock in this case is the Angers quince, which is imported from Europe and which is the same as that used for dwarf pear stocks. Quinces are set when two and three years old from the cutting or bud, but the latter age seems to be generally preferred.

Planting and pruning.—I am convinced that the ideal distance apart for planting quinces is about fifteen feet each way, although most orchards are closer than this. Some of them are even as close as ten feet each way. Too close setting requires heavier fertilizing and better care than most growers are willing to give, it demands severe heading-in, and it seriously interferes with spraying—a practice which can no longer be omitted in this state. The top should be started low, never more than twelve to twenty inches above the ground, I think; and the branches should be allowed to spread widely. The frontispiece (Fig. 1) shows what most New York horticulturists would regard as a model shape for starting the top of quince trees, although there is room for difference of opinion as to the advisability of such severe heading-in each year as this orchard has received. I have already discussed what I believe to be the fundamental necessities for the heading-in of the annual growth of peaches (in Bulletin 74), and the same observation may be applied to quinces: if bearing trees persist in making a heavy growth—say 18 to 30 inches—they should be shortened-in each winter; but if the land and treatment are such that the tree makes a rather slow hard growth, the operation will not be necessary. Under conditions of rapid growth, heading-in certainly induces fruitfulness, and it also keeps the tree within bounds. The real question at issue, however, lies farther back.

Is it wise to induce very strong growth in any bearing tree? Or, is it not better to use rather more potassic and phosphoric fertilizers and rather less stable manures and to be more conservative of late cultivation? These are questions which the grower must answer for himself, for everything depends upon the original character of the soil.* It will generally be found, I think, that some heading-in of quince trees is desirable, especially when the orchard is young. The Maxwell orchard, shown in the frontispiece and which has been fertilized chiefly with stable manure, has probably been the most uniformly successful of any in the state, and a half or two-thirds the annual growth has been cut away each winter; but this does not prove that the same result may not have been accomplished more economically. Shortening-in the annual growth also thins the fruit, for it cuts off all the terminal bloom: the crop, in such cases, is borne upon the tips of the side spurs, and it is less liable, perhaps, to injury from winds.

The crop, and marketing.—If the quince tree is three years old when set—which seems to be the age of tree generally preferred—it should bear a few quinces the second or third year, and from that time the crop should increase each year until its full capacity is reached—a period which comes when the tree is nine or ten years planted. If the orchard is well cared for, it should continue to be profitable for thirty or forty years, and perhaps even longer. If the trees are ten by fifteen feet apart, so that about 300 trees stand upon an acre, an average crop for an orchard in full bearing should be a bushel to the tree of marketable fruit, and in occasional years this crop may be doubled.

Although the quince is not a dessert fruit, the prices are determined very largely by the manner in which the crop is packed and handled. A bruise soon becomes a dark brown spot and detracts greatly from the appearance of the product. The fuzz is commonly rubbed off completely to bring out the orange-like color and surface of the fruit. The Maxwells, at Geneva, make three grades of quinces, aside from the culls, but the latter are usually very few. The best grades and the earlier pickings are shipped in fifteen-pound or peck grape-baskets or in bushel kegs, whilst

* See Bulletin 72, upon "The Cultivation of Orchards."

the main grade is marketed in barrels or half-barrels. The profits ordinarily lie in the two top grades. Prices of quinces vary greatly. This year, most shipments brought poor returns, although the later ones were fairly remunerative, bringing from \$2.00 to \$2.50 per barrel. The quince barrel used in western New York is the so called pony barrel, holding less than three bushels. The quality of quinces was low this year. The fruit did not keep long and it had a decided tendency to crack. The former condition was probably due to premature ripening as a result of the prolonged drought, and the cracking was evidently the result of the fall rains in swelling out the fruit. It is noticeable that the placing of each individual fruit by hand in the small packages, brings fully as good returns as it does in peaches and other desert fruits, and this is a sufficient answer to those persons who say that because the quince is not consumed raw therefore it is not worth while to "fuss with the packing."

Varieties.—The varieties of quince are few, and yet not more than half of them are known in western New York. The only variety which is generally esteemed is the Orange or Apple, which is uniformly reliable and productive, and, being of mid-season, may be used either for early or late market. The variety is not uniform, however. There are various more or less distinct but unnamed strains of it. It tends strongly to reproduce itself from seeds, as I have proved by experiment. While the Orange quince should comprise far the greater part of every commercial quince plantation in this state, I am convinced that a few trees of an earlier variety, like the Rea, and of a later variety, like the Champion, will be found to be desirable. The only varieties which compete for favor in this state appear to be four, the Orange, Champion, Rea, and Meech. Other varieties, of which about a half-dozen have been prominently mentioned, are not yet sufficiently tested to allow of an intelligent report.

Our own quince plantation was set in the spring of 1889, and it comprises, chiefly, the four varieties mentioned above. The first fruits were borne in 1891. Taking the productiveness of the Orange quince per tree as 10 as a basis of comparison, the yields for the various years stand as follows :

	Orange	Champion	Rea	Meech
1892	10	12	2	5
1893	10	8	2	4
1894	10	16	7	8
Average	10	12	3 $\frac{2}{3}$	5 $\frac{2}{3}$

It will be seen, that, so far, the Champion has been most productive and the Rea least productive, while Meech has been about half as productive as Orange. In 1894, the Champion bore over a



3.—Champion. $\frac{1}{2}$ nat.
size.

half bushel to the tree ; and this quantity may be taken as a fair crop for trees of this age. From this time on the yield

should gradually increase in quantity and uniformity. The following notes of these varieties, as grown in the University gardens, may be of interest:

Orange or Apple Quince (Figs. 7 and 8).—Tree of moderately vigorous and spreading growth. Fruit very variable in size and shape, but in the ideal or original form not at all pear-shaped but distinctly flattened on the ends, like an apple. Color bright pale orange, the surface only moderately fuzzy. Midseason, and keeping until February under good conditions.

The great variation in the shape and color of the Orange quince is generally thought to be due to the existence of sub-varieties which have arisen independently from seed, and this is undoubtedly the occasion of most of the differences ; but Fig. 8, which is explain-

ed on page 622, shows that it may sometimes arise from the treatment given the trees.

The old Orange or Apple quince was of European origin, but it is doubtful if the original strain or type is now in cultivation in this country.

Champion (Fig. 3).—Tree an upright grower, taller than the Orange. Fruit large, distinctly pear-form, furrowed about the top, generally remaining greenish-yellow upon the tree, conspicuously covered with a floccose wool or fuzz. Late ; in some places



4.—*Rea (Rea's Mammoth)*. $\frac{1}{2}$ nat size.

it does not ripen well. It is the best keeper which I know. In a comparative keeping test of the four varieties here considered, which was made in an ordinary cellar, the Champion did not begin to get soft and yellow until the middle of January, while the other varieties were at that time showing signs of failing.

The Champion is an American quince of recent origin.

Rea, or Rea's Mammoth (Fig. 4).—Tree small, not over two-thirds the size of the Orange at the same age. Fruit large to very large, mostly abruptly pear-form, rich orange in color, the surface very smooth, flesh of excellent quality. Ripens early, and does not keep so long as the Orange.

The Rea is a seedling, raised some thirty years or more ago, by Joseph Rea, Coxsackie, N. Y. The variety is either greatly modified by the conditions under which it grows, or else it is mixed. It was first described as a vigorous grower, with apple-shaped fruit, but our trees—procured from a reliable source—contradict both these characters. As we have it, it is at once distinguished by the short stature of the tree, and the large size, deep color and smooth surface of the fruit. It is not productive, but the excellent quality of the fruit and its showy size and color, make it worth growing to a small extent for early or fancy markets. It undoubtedly needs high culture.



5.—*Meech* (*Meech's Prolific*). $\frac{1}{2}$ nat. size.

Meech, *Meech's Prolific* (Fig. 5).—Tree very like the *Orange*, but lower. Fruit ranging from nearly apple-shaped to short pear-shaped, somewhat furrowed at the top, covered with a thin fuzz, color of the *Orange quince*. Keeps about as long as the *Orange*.

The *Meech* is supposed to have originated in Connecticut some thirty-five years ago. It was first described and named in 1883 by W. W. Meech, author of *Quince Culture*, as *Pear-Shaped Orange quince*. It was subsequently named for Mr. Meech, who brought it into notice. It is said to be the most productive of all varieties, and this was the reason for its introduction; but with

us thus far, it is not only comparatively unproductive, but the fruits have always been very variable in size and they have been particularly subject to the black-spot. I am hoping that as our trees become older, the variety may sustain its advertized reputation.

The Chinese or Hong Kong quince, which now and then appears in catalogues, represents a wholly distinct species from our ordinary quinces (it is *Pyrus Cathayensis* of botanists), and it is a very distinct and unique fruit, and the tree is wholly unlike an ordinary quince tree. It is not hardy in the northernmost states, although it was fruited in Westchester County, New York, so long ago as 1845. The fruit is oblong and very large, often weighing over two pounds.

Two of the newer quinces of which I have seen fruit and which are promising, are the Johnson and Bourgeat. The Johnson is a mild or sweet apple-shaped quince of the season of the Orange, or a little later. It originated with W. B. K. Johnson, Allentown, Penn. It promises well for home use. The Bourgeat is a variety recently imported from France. It is a firm apple-shaped quince of medium or large size, ripening just after the Orange.

Leaf-blight and fruit-spot.—The quince falls an easy prey to various insects and fungi, although there are only three of the insects and two of the fungous diseases which are serious, in this state, so far as I know. The one most serious and wide-spread perplexity is the fungus (*Entomosporium maculatum*) which spots the leaves (Fig. 6) and causes them to fall early, and produces the black-spot of the fruit (Fig. 7). This disease is probably always present upon quince trees, although it may not always produce serious difficulty. It is undoubtedly most serious in its effects upon orchards in sod, or those which are otherwise neglected. Yet every orchard is liable to be ravaged by the fungus. In most orchards the leaves begin to fall more or less in August and early September from the effect of the disease, and it is not infrequent to see plantations almost entirely defoliated while the fruit is not yet fully grown. In perfectly healthy trees, the foliage should persist until after the fruit is harvested. The loss of the foliage deprives the fruits of nourishment when they are completing their growth, and they usually remain small, and immature;

and it also prevents the tree from laying by that store of energy which is needful for next year's crop. I have often known the attack to come on so early in the season that the fruit appears to become stunted even before it is half grown. But the disease is

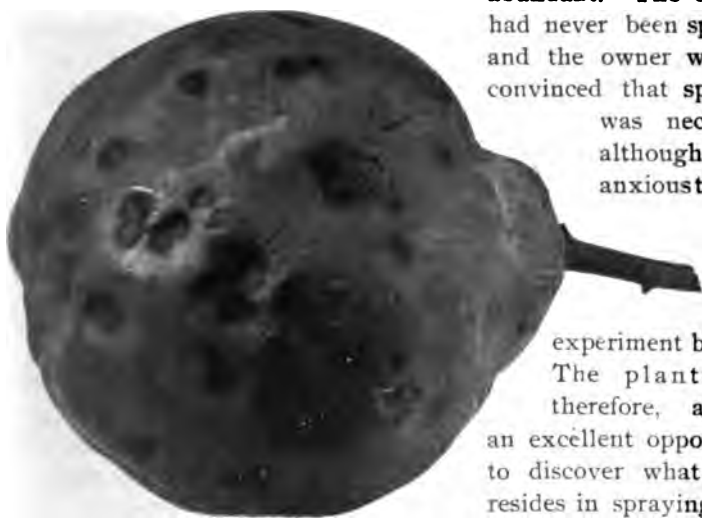


6 — *The leaf-blight. The left hand specimen was not sprayed ; the other was.*

serious upon the fruit itself, as well as upon the leaves. In well tilled plantations, its usual appearance is that shown in Fig. 7 ; but in serious attacks the fruit cracks or becomes lop-sided, the same as pears do when attacked by the same fungus.

Happily, this fungus is readily held at bay by energetic spraying with Bordeaux mixture. This has been proved time and again by various experimenters, but in order to bring the subject home by a test upon a commercial scale amongst our fruit-growers themselves, I this year selected the orchard of Col. H. Bowen, at Medina, in Orleans county, for experiment. This is an orchard in full bearing, comprising Orange quinces, but which has been in sod for several years. The trees are healthy, but moss-grown, and the crops have been indifferent because the fruit is usually small and more or less scabby and it has not been

abundant. The orchard had never been sprayed, and the owner was not convinced that spraying was necessary, although he was anxious that the



experiment be tried. The plantation, therefore, afforded an excellent opportunity to discover what value resides in spraying, inasmuch as there was no fertilizing, tillage, or other

7.—*Black-spot of the Quince (natural size).*
circumstance to complicate the result.*

It was very late in the season (June 25) when the first application was made, for at that time the fruits were as large as the end of one's thumb—an inch long—and the leaves were already badly marked with the small brown spots of the leaf-blight. In fact, I thought that it was too late to obtain any results from the spray. Yet the Bordeaux mixture (6 lbs. sulphate copper, 4 lbs. lime, 40

* The spraying experiments made upon quinces in the University gardens will be reported on in a later bulletin.

gallons water) was "put on to kill," as a spectator remarked. The trees were soused with the mixture, and the entire foliage and the limbs were deep blue as soon as the application had dried. On the 9th of July, the application was repeated. At this time, the first application appeared to have done no good. The foliage was equally blighted in the sprayed and unsprayed portions, so far as I could determine, although the disease did not appear to have progressed much in the meantime. The fruits upon the sprayed portions were much browned and discolored by the Bordeaux. The experiment seemed to be unpromising, and it was not carried further.

On September 21st, the orchard was visited again, and the treatment was found to have brought the most remarkable results! The fruits upon the sprayed rows were nearly twice larger than upon the untreated rows alongside, yellower and less fuzzy, and they were markedly longer in form as well as much more uniform in size. The russet discoloration of the Bordeaux mixture had wholly disappeared. Fig. 8 shows an average quince from each lot, three-fourths natural size. The differences of shape are quite as marked as those of size. While I am unable to account for this change of shape, it was easy enough to see that the increased size was due to the persistence of the leaves upon the sprayed trees. From one-fourth to one-half the entire foliage had fallen from the unsprayed trees, and what leaves remained were small and yellow. On the sprayed trees, however, the leaves were all intact and they were large and dark green. It was noticeable that the tips of the shoots on the untreated trees were almost uniformly bare of leaves, and the leaves which stand directly against the base of the fruit had fallen. Fig. 6 shows two characteristic twigs, the short one upon the left being from an unsprayed tree, the other from a sprayed tree. The leaves upon the shorter twig show the spots of leaf-blight. Fig. 8 shows how the leaves persist next the fruit upon the sprayed specimens, while they fall from other fruits. These leaves must exercise an important office in the growth of the contiguous fruit, for the quince has no stem in the sense in which apples, pears and plums have, but the leafy branch terminates directly in the fruit. I am not sure that I understand why the sprayed quinces were so much less fuzzy than the others,

Average shape and comparative size of sprayed Orange quince. Observe that the leaves still persist at the base of the fruit. Fruit bright yellow and glossy, almost free from fuzz, and very handsome.



Average shape and comparative size of fruit of unsprayed Orange quince. Leaves fallen from the tree. Fruit later, greener and apparently of low quality.

8.—Quinces from adjacent sprayed and unsprayed trees. $\frac{1}{2}$ nat. size.

but I am inclined to think that this woolly covering—which is a living growth from the surface of the fruit—was killed by the Bordeaux mixture. The young fruits, it will be remembered, were much discolored by the Bordeaux, but the absence of any roughness or discoloration upon the ripe fruit apparently shows



9.—*Sprayed limb (on the left) with "moss" or lichen destroyed; unsprayed limb on the right.*

that the injury did not extend deeper than the fuzz. These sprayed fruits were not only larger, yellower and smoother than the others, but they were almost wholly free from spots or cracks of the spot fungus, although none of the fruits in the orchard were seriously attacked. Another marked result of these two sprayings was the complete destruction of the "moss" which had overgrown many of the trees. Fig. 9 shows on the left a branch from a sprayed tree. This was completely covered with the moss when the experiment began, but this moss was killed by the sprays and nearly all of it had fallen off when the trees were examined in September. The branch upon the right shows the moss upon the unsprayed trees.*

The results of these two tardy sprayings, then, were exceedingly satisfactory. In fact, the outcome was more marked than is

* This "moss" is really a lichen. Two species are growing upon the right hand branch. The most abundant light-colored one is *Physcia stellaris*; the dark patches are *Theloschistes concolor*. These were determined by Miss Clara E. Cummings, of Wellesley College.

usually the case, and I should not expect it again even in this same orchard. The plantation had been so completely uncared for in respect to such treatment and to tillage, that it was in just the condition to show unequivocally any advantage which had been gained by the spray. Yet marked results in combatting the leaf-blight are so certain, that nearly all the best quince growers in western New York spray their orchards. The experience in this orchard proves that the spread of the disease may be almost wholly stopped even after the leaves are conspicuously marked by it. The disease cannot be said to be cured in the sprayed leaves, but the fungus is no doubt kept from fruiting and it is confined largely to its original points of attack; and it is not allowed to spread onto the new leaves. It is unwise, of course, to wait until the disease appears before applying the spray. An application of Bordeaux should be made soon after the blossoms fall, and two or three thereafter at intervals of two or three weeks, for the disease may always be expected. Col. Bowen makes the following statements concerning the experiment in his orchard:

I consider the experiment in my quince orchard really marvelous, as do other fruit growers—some of whom visited it several times during the summer and also at picking time. The fruit on the rows of trees sprayed was quite perfect, being as a rule free from black specks, and of extraordinary size, some weighing a pound each, and one barrel containing less than 200 quinces sold in Albany for \$6.00, when ordinary fruit was selling for less than half that price. The foliage on the sprayed trees remained on long after the others had fallen. The spray also killed the moss, and the prevalence of red rust was not as great as on the trees not sprayed. Your experiment here will have the effect, I think, to arouse fruit growers to renewed activity next spring in caring for their fruit orchards of every description.

H. Bowen

Rust.—Another disease which is nearly always present to a limited extent, and which has attracted much attention during the past season, is the rust. It is well shown in Fig. 10. It is very conspicuous upon the fruit, as it covers the injured portion of the quince with an orange fringe-like growth. The tube-like projections of the fungus contain numerous spores, and when this stage is apparent the fruit is already irrevocably ruined. Sometimes

the entire young fruit is involved, and it may die and fall ; but more often the fruit hangs upon the tree and the diseased portion becomes dry, hard, black and sunken. Such a fruit, with the entire top third deformed by rust, is shown in Fig. 11. This rust fungus also penetrates the twigs, and often causes knots to appear, resembling the black knot of the plum (Fig. 12). This fungus has a curious life history. Upon the quince, and some related fruits, it is known as *Roestelia aurantiaca*, but it is really only a form of another and very different looking fungus which causes apple-like swellings upon the twigs of red cedar trees and juniper bushes. Upon these plants the fungus is known as



10.—Rusted young quinces. The left hand specimen is attacked at the blossom end and the other at the stem end.

Gymnosporangium clavipes. This cedar fungus, or so-called cedar-apple, produces its spores in spring, and these are carried by the wind, and, alighting upon the quince, soon produce the rust ; and when this rust upon the quince first attracts attention, it is already beyond control, as I have said, save by removing and burning the diseased parts. The spores produced by the quince rust are incapable, so far as known, of again producing the rust, but they are scattered by the wind and when they come upon the cedar or juniper produce the cedar apple stage. It has been

proved that cedars may affect quinces, or other amenable plants, at a distance of eight miles. Evidently, the first thing to be done is to destroy the cedar trees, if rust is feared. The next thing to do is to destroy all affected portions of quinces, hawthorns, apples and other plants upon which the rust stage appears. There is some question as to how long the fungus persists in the quince wood. It has been thought that the mycelium or vegetative portion is perennial in the tissues of its host, but this is doubtful. I believe that the rust can be kept off the quince by thorough spray-



11.—*Quince deformed by the rust (nat. size.)*
The Quince fruit normally has a full rounded apex, but in this fruit the upper 3d is sunken.

ing with Bordeaux mixture. The disease was certainly less prevalent in the sprayed portion of Col. Bowen's orchard than in the unsprayed part. If the leaves, fruits and twigs of the quince tree are covered with the fungicide, the spores will find small chance of making successful germination when they arrive from the cedar trees. But this rust is rarely very serious, and if the grower has sprayed dutifully for the leaf-blight, he will have little to fear.

Pear-blight or fire-blight is undoubtedly the most serious disease with which the quince grower has to contend. It is the same disease which is so destructive to pear orchards in certain years, and which attacks various sorts of apples, particularly the crabs. This is known from all other diseases by the death of the entire

shoot or branch, and the uniform browning and dying of all the leaves involved. In the true fungous diseases, as the leaf-blight already described, the leaves become spotted and they eventually turn yellow and fall ; but in this fire-blight the leaves are uniformly dead brown throughout, and they wither and hang upon the limb. The bark of the diseased branches becomes hard, dry and shrunk. Unfortunately, there is no remedy for this disease, save to cut off the affected parts

and burn them. This treatment destroys the disease, for it is local in its destruction but other attacks may occur. Or-
ease is not serious if it is carefully this way, but in occasional years prevalent as to overcome all ob-
large blocks in the orchard.

Insects.—Three

insects are troublesome to quince growers in western New York, the borer, codlin moth, and quince

curculio. These are well known invaders and it is not necessary to make any lengthy account of them here. The borer,—which is particularly partial to the quince—should be dug out. If the trunks and crowns are examined in May or June and again in September or October of each year, all serious trouble may be averted. It is doubtful if the many strong smelling and caustic washes which are



12.—Quince knot caused by the rust fungus. An infrequent injury of quince shoots, in appearance like the black-knot of plums.

recommended are really efficient. Some growers recommend tarred paper tied tightly about the crowns of the trees for the purpose of keeping away the borers*. The following experience

*Serious results often follow the use of tarred paper tied about trees, for the bark is likely to die underneath the paper. This is especially true if the paper is left on during the growing season, and the trouble seems to be

however, given me by F. H. Wakeley, Greenville, Green Co., N. Y., makes me cautious about advising its use:

"Twelve years ago, I set three hundred apple trees and the mice and borers went for them till I was about discouraged. So one November I wrapped about one hundred trees with tarred building paper. Some were small trees, set about one or two years before, others were two to three inches through. Next June I noticed that one of the young trees was failing and I found the bark dead as far as the paper touched it. I stripped the rest of the trees quickly. Trees the size of my thumb were all killed, while in the larger ones the outside bark turned black and peeled off. If I had left it on through the summer I think it would have killed every one. I have tried soap, ashes, etc., with poor success. I know of one orchard that is wrapped with pieces of wire screen such as is used for windows, and it appears to fill the bill. I shall try it when I set more apples."

The codlin moth is the same insect which delights in the apple. It is less serious in the quince. The best remedy is to add Paris green to the Bordeaux mixture which is applied for the leaf-blight. The poison should be added to the Bordeaux mixture in the same proportion as if the latter were water; that is, one pound of Paris green is added to 250 gallons of the mixture.

The quince curculio is closely allied to the plum or peach curculio. It punctures the fruit and causes it to become rough and knotty. The Maxwell's, with whom it is very bad, have tried to dislodge it with Paris green, but with little success. The best method is undoubtedly to catch the insects upon sheets in the same manner as the plum curculio is captured. Certainly, one is sure of the bug when he gets him between his fingers.

greatest upon young trees. It is possible that different brands or grades of tarred paper behave differently in the effect upon the bark. In Bulletin 69, p. 254, I said that tarred paper may be used to keep mice away from trees, but I recommended that it be "rolled lightly about the base of the tree," not tied; and inasmuch as mice are never troublesome in warm weather, it is presumed that the paper will be removed in early spring. But even with these precautions, it may not be wise to use the material unless the grower has had some experience with

REVIEW.

Quince growing is an important interest in western New York, where it has no doubt reached its largest dimensions in North America.

As a rule, quinces bring only ordinary profits, owing to the limited demand for the fruit, but this difficulty may be in a measure overcome by searching out distant or unsupplied markets.

The crop is reliable ; that is, it is not easily destroyed by capricious variations in weather, the trees are hardy and productive, they are easy to prune and spray, and the diseases and insects, while rather numerous, are held in check with comparative ease, with the single exception of the pear-blight.

The best soils for quinces in western New York, are thought to be the heavy clay loams. The lands should be retentive of moisture, but not wet and soggy. Good drainage is essential to quince culture, as it is to the growing of pears or other fruits. See page 610.

So far as known, the general plan of fertilizing quince orchards should be that which is also best adapted to apples and pears,—the free use of potash and phosphoric acid, and the conservative use of nitrogen. It is probable that, upon good quince lands, most or all the necessary nitrogen can be obtained by tillage and cover crops. See page 610.

Quince orchards should be given clean culture. The best results cannot be expected if they are kept in sod. The roots are usually shallow, however, especially if the land has not been cultivated from the first, and very shallow tillage is generally best. It is sometimes impossible to plow up old soddy orchards, and in this case the fertilizers may be sown upon the sod, and the land can be subdued by dragging or cultivating lightly when the sod is soft in spring. See page 612.

Probably the best results will be obtained, in the long run, if the trees are set fourteen or fifteen feet apart each way, although they are commonly planted closer than this.

The quince tree should have a trunk twenty inches or less high. The pruning is essentially the same as that demanded by

the apple, except that it is generally found to be advisable to shorten-in the annual growth somewhat each winter. Whether this shortening-in shall be practiced, as well as the extent to which it shall be carried, depends almost entirely upon the growth which the tree is making. See pages 611 and 613.

The first fruits of consequence may be expected when the tree is three or four years planted, although the quince does not arrive at full productiveness until it is nine or ten or more years old. An average crop for an orchard in full bearing is one bushel of first-class fruit to the tree, but this yield is exceeded in some years. Careful attention to handling and marketing pays as well with the quince as with other fruits. Shiftless men are never successful fruit growers.

The Orange or Apple quince is the only variety which is commonly planted. The Champion is a better keeper and equally productive, but it is too late for some localities. Rea is an early variety of large size, but the tree is small in stature and it is not very productive. See pages 615 to 619.

The fungus which causes the blight and falling of the leaves (Fig. 6) and the spotting and cracking of the fruit (Fig. 7) is the commonest enemy of quinces in this state; but it is readily held in check by spraying with Bordeaux mixture. See page 619 to 625.

The rust is a curious disease which is always fatal to the fruits which it attacks (Figs. 10-12), but which is rarely seriously prevalent. One stage of the fungus which causes it occurs upon red cedars and junipers, and the destruction of these plants is the first means of prevention. All attacked quince fruits and twigs should be burned. It is probable that the thorough spray of Bordeaux mixture which destroys the leaf-blight will also prevent the rust fungus from obtaining a foot-hold.

Pear-blight is the most serious disease of quince trees, and there is no way of keeping it in check but to cut off and burn all affected limbs. See page 627.

Three insects are mischievous in western New York quince orchards: the borer—search for it twice a year; the codlin moth—put Paris green in the Bordeaux mixture; and the quince curculio—jar it onto sheets, as you would the plum curculio.

L. H. BAILEY.

130.679
N7
C82b

UNIV. OF
CORNELL

Bulletin 81.

December, 1894.

Cornell University Agricultural Experiment Station.

HORTICULTURAL DIVISION.

BLACK-KNOT

OF

Plums and Cherries, and Methods of Treatment.



By E. G. LODEMAN.

PUBLISHED BY THE UNIVERSITY,
ITHACA, N. Y.
1894.

ORGANIZATION.

BOARD OF CONTROL:

THE TRUSTEES OF THE UNIVERSITY.

STATION COUNCIL.

President, JACOB GOULD SCHURMAN.

Hon. A. D. WHITE,	-	-	-	-	Trustee of the University.
Hon. JOHN B. DUTCHER,	-	-	-	-	President State Agricultural Society.
Professor I. P. ROBERTS,	-	-	-	-	Agriculture.
Professor G. C. CALDWELL,	-	-	-	-	Chemistry.
Professor JAMES LAW,	-	-	-	-	Veterinary Science.
Professor A. N. PRENTISS,	-	-	-	-	Botany.
Professor J. H. COMSTOCK,	-	-	-	-	Entomology.
Professor L. H. BAILEY,	-	-	-	-	Horticulture.
Professor H. H. WING,	-	-	-	-	Dairy Husbandry.
Professor G. F. ATKINSON,	-	-	-	-	Cryptogamic Botany.

OFFICERS OF THE STATION.

I. P. ROBERTS,	-	-	-	-	Director.
E. L. WILLIAMS,	-	-	-	-	Treasurer.
H. W. SMITH,	-	-	-	-	Clerk.

ASSISTANTS.

M. V. SLINGERLAND,	-	-	-	-	Entomology.
GEO. C. WATSON,	-	-	-	-	Agriculture.
G. W. CAVANAUGH,	-	-	-	-	Chemistry.
E. G. LODERMAN,	-	-	-	-	Horticulture.
MICHAEL BARKER,	-	-	-	-	Horticulture.

Office of the Director, 20 Morrill Hall.

Those desiring this Bulletin sent to friends will please send us the names of the parties.

BULLETINS OF 1894.

62. The Japanese Plums in North America.
63. Co-operative Test of Sugar Beets.
64. On Certain Grass-Eating Insects.
65. Tuberculosis in Relation to Animal Industry and Public Health.
66. Test of Cream Separators.
67. Some Recent Chinese Vegetables.
68. The Cultivated Poplars.
69. Hints on the Planting of Orchards.
70. The Native Dwarf Cherries.
71. Apricot Growing in Western New York.
72. The Cultivation of Orchards.
73. Leaf Curl and Plum Pockets.
74. Impressions of the Peach Industry in Western New York.
75. Peach Yellow.
76. Some Grape Troubles of Western New York.
77. The Grafting of Grapes.
78. The Cabbage Root Maggot, with notes on the Onion Maggot and Allied Insects.
79. Varieties and Leaf-Blight of the Strawberry.
80. The Quince in Western New York.
81. Black-Knot of Plums and Cherries, and Methods of Treatment.

CORNELL UNIVERSITY, ITHACA, N. Y., December 15, 1894.

THE HONORABLE COMMISSIONER OF AGRICULTURE, ALBANY,

Sir.—The following account of the black-knot of plums and cherries is submitted for publication and distribution under section 87, chapter 675, of the laws of 1894. The subject is an important one to all fruit growers, and the present account contains the first experimental proof that the disease can be kept in check by spraying. The leading points established in this paper are these: The disease usually shows itself the year following inoculation, a fact which is proved by the absence of knots on the growth of the season; the inoculation occurs mostly in crotches and at the junctures of the annual growths, owing to the greater frequency of chinks at these places, and to more tender bark, and to convenient places for lodgement of the spores; if the branches are constantly covered with fungicide, the germinating spores are killed. Good Bordeaux mixture remains upon the branches a long time, and it appears to retain its efficacy from the fact that when applications ceased early in June the summer spores of the fungus, which no doubt appeared after this time, were apparently unable to seriously multiply the disease. Whilst the results with the spray are surprising, there is nevertheless every reason for anticipating them, for it is evident that the infection takes place from spores falling upon the plant, and it is generally understood that germinating spores are killed by copper fungicides. Mr. Lodeman's results with the black-knot are supplemented by similar results obtained by myself upon another fungus which enters the deep tissues, the red rust of the quince (see Bulletin 80).

L. H. BAILEY.

BIBLIOGRAPHY OF THE BLACK-KNOT.

1819. Peck. Mass. Agric. Repository, p. 307.
1821. Schweinitz. Synopsis Fungorum Carolinae Superioris, No. 134, p. 40.
1825. Thatcher. The American Orchardist, 2d ed. p. 223.
1826. Buell. N. E. Farmer, Jan. 20.
1831. Schweinitz. Synopsis Fungorum Amer. Bor. Proc. Phil. Soc. III. p. 269.
1833. Kenrick. New American Orchardist, p. 271.
1838. Manning. Book of Fruits, p. 33
1843. Burnett. Hovey's Mag. of Hort. IX. p. 288.
- . Burnett. N. E. Farmer, Aug. 16, p. 49.
1844. Ives. New England Fruit Book, 2d ed. p. 102.
1849. Jaques. Practical Treatise on the Management of Fruit Trees, p. 229.
1850. Hodge. The Cultivator, p. 333.
1852. Harris. Insects Injurious to Vegetation, 2d ed. p. 69.
1855. Griffen. The Country Gentleman V. p. 106.
1858. Thomas. American Fruit Culturist, p. 320.
1863. Austin. American Agriculturist, p. 113.
- . Glover. U. S. Agric. Report, p. 572.
1864. Walsh. Proc. Ent. Soc. Phila., III. p. 613.
1866. Riley. Gardener's Monthly, Nov. p. 331.
- . Hicks. Ibid. p. 335.
- . Walsh. Practical Entomologist, I. p. 48.
1867. Walsh. Ibid, II. p. 63.
1870. The American Entomologist and Botanist, II. p. 231.
1872. Peck. A Paper on Botany. Report to Albany Institute, Feb. 6.
1875. Taylor. Monthly Microscopic Journal, VIII. p. 118
1876. Farlow. Bulletin Bussey Institution, Part V. p. 440.
1879. M. B. B. The Country Gentleman, 44, p. 262.
1884. Saccardo. Sylloge Fungorum, III. p. 445.
1885. Crozier. Botanical Gazette, p. 368.
1889. Maynard. Mass. Hatch Agric. Exp. Sta., Bulletin 4.
1890. Scribner. Fungous Diseases of the Grape and Other Plants, p. 111.
- . Butz. Rep. of Penn. State College, p. 166.
- . Humphrey. Mass State Agric. Exp. Sta., Eighth Annual Report, p. 200.
1891. Maynard. Mass. Hatch Agric. Exp. Sta., Bulletin 11
- . Halsted. N. J. Agric. Exp. Sta., Bulletin 78.
1892. Beach. N. Y. State Agric. Exp. Sta., New Series. Bulletin 40,
- . Humphrey. Mass. State. Agric. Exp. Sta., Rep. of Mycologist, p. 27.
1893. Sturgis. Conn. Agric. Exp. Sta., Bulletin 115, p. 9.
1894. Lodeman. Garden and Forest, No. 356, p. 508.

THE BLACK-KNOT OF PLUMS AND CHERRIES, AND METHODS OF TREATMENT.

Distribution—Many of our stone fruits, both the wild and the cultivated forms, suffer from the attacks of a disease which is popularly known as the black-knot. It is of American origin, and from the early records of its presence on cultivated trees, it appears to have been particularly abundant along the northern half of our Atlantic sea-board. This may be ascribed to the fact that this portion of the country was first most thickly settled and consequently such a trouble would there be first noted. In the early part of this century, however, the disease had become more serious in most of the regions in which it was first mentioned, and the ruinous effects of its presence gradually became known in those sections which appear to have been free from the trouble at the time the first settlements were made. It is not improbable that the disease was first restricted to the country east of the Alleghany mountains, although several of the plants upon which it is found are native in the regions to the west. It appears that no serious damage was done by the fungus in western orchards until the number of its cultivated host plants had become sufficiently great to allow of the rapid propagation and spread of the disease. In some cases its presence could be traced directly to an eastern source.

In *The Cultivator*, for 1850, page 333, is the note that "Benjamin Hodge, of Buffalo, N. Y., who has raised and sold trees for the past 30 years says he never had this malady among his plum trees till the present season, and that in the instance cited it was introduced from the east." He further claimed that all the affected trees came from stocks brought from Massachusetts. In 1879 the statement was made* that the knots were appearing

* *The Country Gentleman*, vol. 44, p. 262.

about Cincinnati in regions which had previously been free from the disease. Other cases of a similar nature might be mentioned, and although the disease may have been native to a large area, it appears to have attracted attention only after the cultivated plants upon which it thrives had been generally grown, and the conditions for its rapid dissemination had become favorable. At present the disease is confined to North America, no case of its occurrence in Europe or foreign countries having been reported. It is found throughout the United States, but is rare in the extreme south.

Description.—The superficial characters of the parts attacked by this disease are familiar to nearly every one who is in any degree interested in the extermination of the pest. The term "black knot" is very expressive, for the affected parts swell and present the form of more or less elongated knots which turn a deep black during the fall and winter. According to Humphrey* the newly forming knot can often be seen in the fall. It then appears "as a slight swelling of the branch, arising near an old knot, or independently." It is generally in the spring, however, that the knots can first be plainly seen. Affected portions commence to swell as soon as the active flow of sap begins, and as the swelling increases the bark is ruptured and a granular growth soon fills the crevices. This newly formed substance is light yellowish brown in color, and a tinge of green can sometimes be seen. The brown shade deepens as the season advances. During the latter part of May and early in June the swellings have enlarged to such an extent that they are frequently three to four times the diameter of the twigs upon which they are found. The bark very soon disappears, and the knot is found to be composed of a mass "in which all distinction between wood and bark has been lost. In the knot we find bast fibres, wood cells, and dotted ducts; but the prevailing tissue consists of a collection of dotted, rectangular, parenchymatous cells, with very thick walls which closely resemble the walls of the medullary rays."† The knot also gradually

* Eighth Annual Report of the Mass. State Agric. Exp. Station, p. 205.

† Farlow, Bull. of the Bussey Institution, Harvard University. Part V. p. 446.

changes color ; and eventually it is perfectly black and presents the appearance which is so commonly seen, Figs. 3 and 4.

There is much variation in the size, shape, and location of the knots. Sometimes they do not grow to be more than a quarter of an inch in length, and then they do no particular damage. Such small knots are seldom seen, for their growth in spring is generally quite rapid and they frequently extend several inches along a twig. The largest knot which has come to my notice was on Morello cherries and was nearly five inches in length, it being all one year's growth. If the growth of other years is considered, the diseased portion will be considerably extended. It is a peculiar circumstance that the knots as a rule do not encircle a branch, but nearly all extend along the branch upon one side while the portion opposite remains healthy and permits the passage of the sap to the living portions beyond. Small twigs are frequently killed outright, for in them the disease soon cuts off all communication between the parts above and those below the affected portion. Large limbs do not succumb so rapidly. The disease gradually extends from year to year and it may be a long time before the death of the parts beyond takes place, for such, with probably rare exceptions, is the result which eventually follows the appearance of the trouble.

The form of the knots varies considerably. Upon the smaller branches, those two or three years of age, they are generally straight, or nearly so. The swelling is often more marked at the center of the diseased portion, and gradually diminishes towards the ends ; but the swelling may have nearly the same diameter throughout its length, and in such cases the knot terminates abruptly. If the twigs are but a year or two old the presence of the knot may cause considerable bending of the wood, so that frequently the knot turns at a sharp angle, or it may be inclined to the form of a spiral. Large branches which cannot be affected in this manner generally cause the formation of knots that are more or less oval in outline, the most protruding portion being near the center. When the knots are formed in the forks of two branches, as so frequently occurs, they extend along both branches beyond the point of union, and also downwards. Such knots vary greatly in form.

The large majority of the knots found upon Morello cherries seem to form in the following places: in the crotches of younger limbs, at the union of the consecutive growths of two seasons, and upon small spurs which commonly bear the fruits. I have seen some the cases in which it appeared as if entrance had been gained in the axil of a leaf, or about the bud situated at its base. The swellings frequently form in the crotches of limbs that sometimes are four or five years old, but younger branches suffer to a very great extent. The knots which form at the union of the growth of different seasons may generally be found upon wood that is from one to three years of age. The center of the swelling is, as a rule, near the point of union. (See also page 646.) I have as yet failed to find in autumn or winter a well developed knot which was formed upon the growth made during the preceding spring and summer. They have invariably appeared upon older wood, and generally in the positions mentioned above. (See Fig. 3 page 645.)

During May and June the newly formed knots are covered with a velvety growth, but this soon disappears. The knot then becomes dark and by winter has become perfectly black. It is then covered by innumerable, small elevations which project from its irregular granular surface. At this season the knot is generally hollowed out by insects which have developed within, and so there is often not much more than a mere crust remaining. During the fall and early winter many of the knots become more or less coated with a substance which is yellowish white, and other colors may also be seen. This appearance is not a development of the knots, but is caused by a fungus which is parasitic upon them.

Cause.—It is only in recent years that the true cause of the black knot has been demonstrated. Formerly the trouble was generally supposed to be due to the work of insects, and this opinion is still held by many, although scientists have shown plainly that insects are not responsible for such swellings. Other theories were also freely advanced, such as a diseased condition of the sap, abnormal condition of the plant's "constitution," the character of the soil in which the trees were growing, and some form of mechanical injury. But such ideas were not so commonly accepted.

Black knots are now known to be brought on by a fungus, *Plowrightia morbosa*. It was long suspected that such is the case, for the fungus was imperfectly described by Schweinitz as early as 1821.* But the first published statement that the black-knot is caused by a fungus appears to have been made by Dr. Joel Burnett, of Southboro, Mass., although no proof of the proposition was given.† It was based upon the fact that the curculio, which is a regular inhabitant of the knots, did not lay its egg in them until the latter had formed, and thus it could not be held as the cause of the first appearance of the swellings. It was not until 1876 that the relation between the knots and the fungus was clearly shown.‡ Dr. W. G. Farlow then removed all doubt as to the cause of the disease, and although the entire life history of the fungus is not described, no further question can be raised as to the origin of the trouble. The following plants also seem to suffer from this disease: Chickasaw plum (*Prunus angustifolia*), beach plum (*P. maritima*), native red or yellow plum (*P. Americana*), choke cherry (*P. Virginiana*), wild black cherry (*P. serotina*), wild red cherry (*P. Pennsylvanica*). The sweet cherries (*P. Avium*) are said to suffer occasionally, but no authenticated case seems to be on record.§

The life history of the fungus as now understood is in brief as follows: || The first external appearance of the disease is an enlargement which may be visible in autumn but is most marked in early spring. This swelling is caused by the irritation of the fungus which has entered the cambium layer of the branch. This layer is the one from which the inner bark and the wood are formed, and the presence of the fungus causes an abnormal growth to take place (see page 638). The first crop of spores are matured in May and June, and it is these and the threads bearing them which give to the knots the velvet coating they possess at this time of the year. The spores mature quickly and they are then scattered

* Synopsis Fungorum Carolinæ superioris, No. 134.

† *New England Farmer*, August 16, 1843.

‡ Harvard University Bulletin, Bussey Institution, Part V., 1876, p. 440.

§ I once collected knots from a tree of *Prunus Avium* in southern Delaware. The tree, which was of the mazzard or wilding type, was a foot or more in diameter of trunk, and the small limbs bore very numerous well developed knots.—L. H. BAILEY.

|| A list of the most important papers relating to the black knot disease may be found on page 636.

by various natural agencies. The knot then assumes a darker color and presents its characteristic hard, almost metallic appearance.

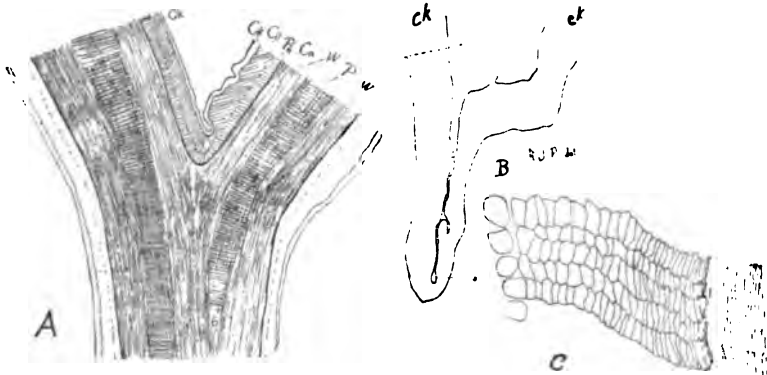
Another crop of spores is still to be borne before the knot has finished its work. These spores are formed in the small pimple-shaped elevations which appear on the surface of the knots in autumn and winter. They mature during midwinter or early spring, the time appearing to vary in different localities. As soon as they have ripened they leave the minute elevations in which they were formed, and are scattered to propagate the parasite in some other spot. The central portion of the knot has then finished its round of existence, but the outer portions continue to grow and form new knots above and below the old one. In this manner a single knot may in time extend a long distance on a branch.

Many points regarding the development of the black knot fungus are still imperfectly known. Two of the more important of these are the time and the manner in which the spores succeed in gaining an entrance into the host plant.

At present it can only be assumed that the spores germinate and penetrate the tissues soon after becoming ripe. The principal periods of infection would then be early spring, as soon as vegetation begins, or even earlier; the other period would be from the middle of May to the middle of July, the time varying with the character of the season and with the locality. This subject is of the greatest importance when considered in its relation to the most favorable times for making applications designed to prevent the entrance of the fungus into healthy tissues.

From the fact that new knots show the first external indications of their presence only to a very limited extent in the fall, while the great majority of them do not form until spring, it would seem that infection takes place one year, but the knot does not develop until the following season. The manner in which the spores that mature in winter invest healthy tissues is not clear. There may be some relation between them and the formation of knots upon older wood, but the production of the spores in summer prevents the making of any definite statements which are not based upon careful artificial inoculations. As already stated, a great many knots are found in the forks of young branches, Fig. 3, 1, and at

the places in which one year's growth stopped and that of the following year began, Fig. 3, 2. A careful examination of the forks of the small limbs shows that the union of the two parts is not so close as at first appears. The cellular structure of these parts, as revealed by the microscope, is seen to be such that the spore of a fungus would apparently have less difficulty in gaining an entrance here than in almost any other place. Figure 1, A, represents a section made at the union of two twigs. The different parts of the limb are here shown so that their relative positions may be understood. The outer layer *ck* is composed of cork cells. These are penetrated with difficulty by the threads from a germinating spore, and it may be that entrance is entirely prevented by them. The layer lying under the one composed of cork cells is the cortex, *co*. This layer as a rule contains no cells which are lignified, or woody, but is composed of cells which are easily penetrated by the mycelium of many fungi. Underneath the cortex is a layer known as the



1.—Crotch of branches where knots often form.

phloem. The phloem comprises the hard and the soft bast cells, only the former being woody. The soft bast cells can also be penetrated by the threads of the mycelium and offer no obstacle to the passage of such parasites. In this manner a fungus can penetrate without much difficulty to the cambium layer, *ca*, represented only by a dark line, when once the layer of cork cells has been passed; for the woody or lignified cells are arranged in isolated bundles so that they do not interfere with the inward growth of the threads of the mycelium, or vegetative portion of the fungus.

Diagram B of Fig. 1 represents only the layer of cork, more high-

ly magnified, as found in the crotch of two small limbs. It will be noticed how deep is the crevice which extends downward from the point at which the two parts are apparently united. Another interesting feature of the diagram is the variable thickness of the layer. Where fully exposed to the air it is comparatively thick, but within the crevice it is much thinner, especially so in a few places. Diagram C shows the layer magnified still more, a section having been taken at the point *c* in B. The center cells are flattened to such an extent that they cannot be plainly seen.

Figure 2 represents a highly magnified termination of another

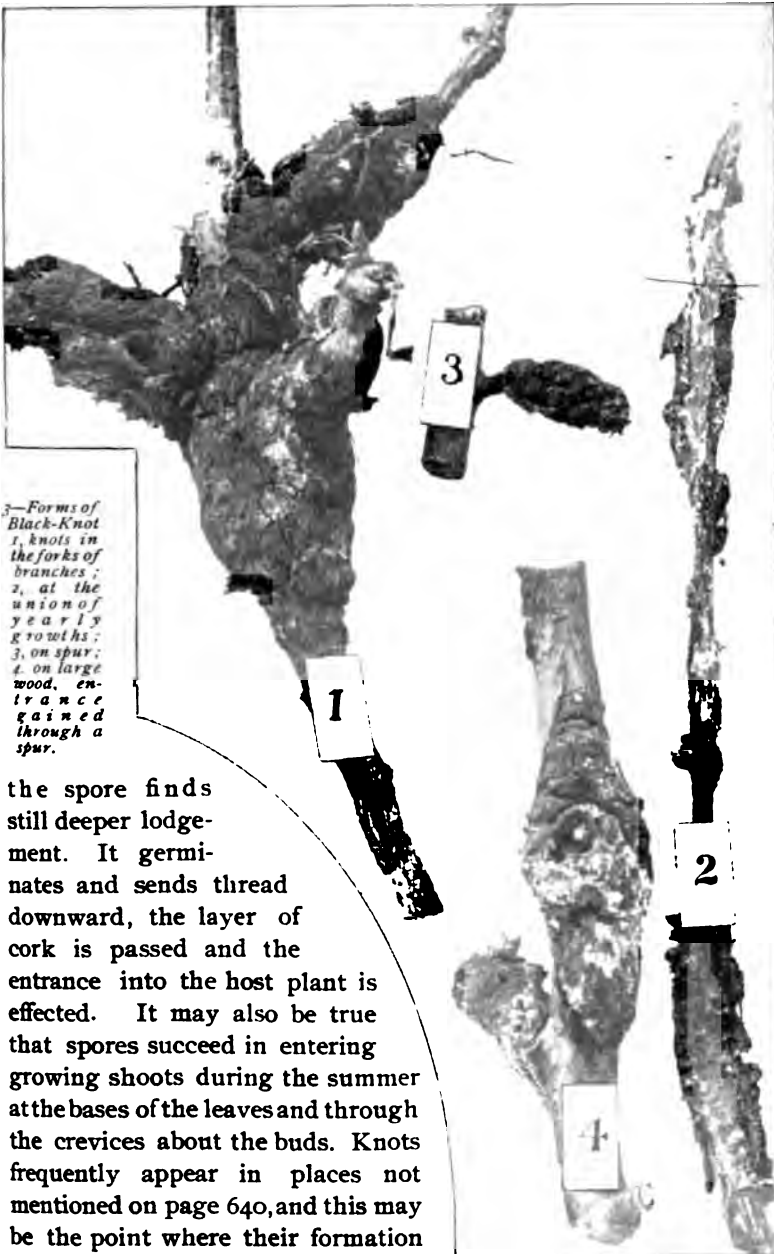


2.—Lodgement for spores in a crotch.

crotch taken from a Morello cherry tree the wood being two and three years old. The point *b* in this diagram corresponds with *b* in diagram B of Fig. 1; it is the lower extremity of the cork layer. But this fork shows a fissure which prolongs the crevice naturally made. The layer of cork cells has been separated, and an opening made into the cortex lying underneath. The cells surrounding the fissure

were tested for corky tissue and also for lignin, or woody fibre. These two substances were found not to be present. The threads of mycelium would therefore have little trouble in gaining an entrance. The fissure seen below *b* was not a new one, for the cell walls surrounding it were darkened as by exposure to air, and it is probable that they exist quite commonly in the forks of Morello cherry twigs.

The manner in which the black-knot fungus gains an entrance into the forks of the smaller branches may thus be made fairly clear. A spore lodges in the crevice between the two branches; the action of the wind and the weight of the branches, especially when wet and bearing foliage, open the crevice more or less and



the spore finds still deeper lodgement. It germinates and sends thread downward, the layer of cork is passed and the entrance into the host plant is effected. It may also be true that spores succeed in entering growing shoots during the summer at the bases of the leaves and through the crevices about the buds. Knots frequently appear in places not mentioned on page 640, and this may be the point where their formation begins.

Number 2 in Fig. 3 shows two knots, each at the end of the growth of a season. The small lines running across the twig at the point of union of the parts formed in different seasons represent elevations and depressions in the surface. These would also afford protection and moisture to any spores which might lodge there.

A microscopic examination shows also some very thin layers of bark, and it seems probable that an entrance could be effected here without much difficulty, provided atmospheric conditions are favorable.

Number 3 of the same illustration represents what may be considered as an explanation of the appearance of knots upon older branches (Fig. 4), or even upon the trunks of the trees. There can still be seen the remnants of small spurs which were probably first attacked. From these spurs the fungus entered the cambium layers of the larger portion, and thus the knot formed, and the part appears to have been directly attacked, although entrance in reality was gained through the spur, as is shown in No. 4 of the same figure.

These examples and many others of a similar character indicate that it is only comparatively young wood that is affected, the covering of the larger branches being so thick that it can withstand the attacks of the disease.

Remedies.—Although the black-knot fungus has been troublesome

almost from the time that the stone fruits which it attacks have been grown in this country, no remedy has yet been found



4.—Knot upon a large branch.

to be of value. The earlier literature upon the subject contains considerable advice regarding the treatment of the disease, but as its nature was not understood such remedies were founded mostly upon an unreliable basis. For example, it was recommended to dig about the base of the trees in the fall, and to keep chickens; the use of two or more quarts of salt per tree was considered of value; pulverized blacksmith's cinders scattered about the base of the trees prevented the disease; iron filings or scraps of old iron answered the same purpose; much importance was also attached to the nature and drainage of the soil in which the trees were growing. This list by no means includes all the suggestions made.

The preventive measure of cutting out the knots as fast as they appeared was strongly recommended from the earliest time, and this is still one of our best methods, if not the best, of checking the spread of this pest. The best time to do the work is in early spring when the new knots can be seen. This prevents the production of both crops of spores and will undoubtedly soon rid a neighborhood of the disease if the work is properly done. The next best time is in the fall, before the second crop of spores have matured. If the work is postponed until after these spores have been distributed the value of the operation will be almost entirely lost. From two to three inches of apparently sound wood should be cut away below the knot in order that no part of the fungus will remain in the portion left upon the tree. It has been generally advised to cover the cut surfaces with some material to prevent further infection at this point. Shellac, paint, and a solution of copper sulphate have been recommended for the purpose, but the value of the practice has not yet been determined and the labor of covering such surfaces may be very great. When the knots have been removed they should be buried or burned, so that no spores may mature after the operation, as sometimes occurs when the knots are left lying upon the ground. One individual cannot exterminate the fungus in a locality, and if no laws exist demanding the destruction of the knots, public sentiment should be brought to the point of making such demands. Laws framed for the purpose of controlling the black knot now exist in Michigan,

New Jersey, New York, and Ohio.* California possesses laws aimed to keep all contagious plant diseases out of the state by means of the inspection of all imported stock ; Ontario and British Columbia also possess laws designed for the better prevention of certain diseases of plants. If existing laws were enforced the extent of injury from the black knot fungus would be very greatly diminished. Unfortunately the above measures have not in all cases been as effectual as was hoped, and individual efforts are still required to free a locality from the pest.

The black-knot fungus may be destroyed while upon the tree, but the operation is tedious. The knots are painted with some liquid which will penetrate their interior, or form a coating over them which excludes the air. As early as 1855 spirits of turpentine† was used for this purpose. Kerosene was used in the same manner ten or fifteen years later, and linseed oil has been tried with apparent success. Kerosene and turpentine must be used with caution, for if a heavy application is made the branch beyond the diseased point will be destroyed and I have seen young plum trees killed outright by a too free use of kerosene. Linseed oil can be used with safety. It is advisable to use some coloring matter, as the red oxide of iron or white lead, to show what parts have been well covered. But the best way of disposing of the knots is to cut them out and burn them.

Since the discovery of the fungicidal properties of some of the copper compounds the remedies which are effective in controlling other fungous diseases have, to a limited extent, been recommended for the prevention of black knot. Very few, however, seem to have tried the experiment. The only recorded case which I have found is that of Maynard.‡ Certain plum trees were sprayed April 19 with a solution made by dissolving one pound of copper sulphate in twenty-two gallons of water. May 19 the application was repeated, but Paris green was added at the rate of one pound to five hundred gallons of the solution. This injured the foliage severely, so the Bordeaux mixture was used for later treatments which were made May 21 and 29, June 7 and 17, July

* A copy of the New York law may be found on page 392, Bulletin 75 of this station.

† *The Country Gentleman*, 1855, p. 106.

‡ Mass. Hatch Agric. Exp. Sta. Bull. 11, Jan. 1891, p. 19.

19 and 29. The conclusion reached was that "the number of warts was *very decidedly* less where treated with the copper mixture, than where untreated * * * and we believe that the plum wart may be held in check by this remedy."

In the spring of 1893 some experiments were begun with the intention of carrying on the work at least two seasons. A thicket of Morello cherry trees and sprouts was chosen for one field of operations. The plants were well covered with knots at the time, and these were all allowed to remain until the following year. The piece was divided into two nearly equal parts by cutting out the brush across a convenient portion of the strip. One part was treated and the other was not. The only fungicide used was the Bordeaux mixture. This was applied in 1893 upon the following days: March 29, April 18, May 6 and 30, and June 13. The trees were as well covered as could be done, but some of the parts were difficult of access.

The work was continued in 1894, and after one application had been made all the knots were cut out. This was done April 25, and the knots from each portion were counted so that the relative number of branches in each portion could be estimated and a basis for comparison might be made when the knots should again be cut. They had been allowed to remain on the tree during the preceding year so that the chances for further infection should be as favorable as possible. At the time of their removal no marked difference could be seen in favor of either portion as regards the relative abundance of the knots, although on the sprayed portion they may not have been quite so thick.

The Bordeaux mixture was again used in 1894. It was applied to the same portion treated in 1893 and upon the following dates: April 9 and 25, May 21, June 6 and 27, July 10 and 20, and August 1. This number of treatments gave the limbs and foliage a blue color which they retained until the leaves fell to the ground, and at this writing, December 3, the branches still show a decided coloration.

Figure 5 represents the thicket as it appeared November 26 before the knots were cut out after the summer's growth. The illustration does not represent plainly the number of knots present, but it will be noticed that there are many more on the unsprayed



5.—Spraying for Black-Knot. Photograph taken in November, before the knots were cut. The line A B marks the division of the plants. Left hand part untreated, the other sprayed with Bordeaux Mixture.



6.—*Spraying for Black-Knot. The same as Fig. 5, after the knots were cut. Observe the severe pruning of the untreated part (to the left) as a consequence of the removal of the knots.*

than upon the sprayed part. The line between the two plots passes across the page from *A* to *B*. The knots were all cut out after the photograph was taken. The appearance of the thicket after the operation is shown in Figure 6. It will be noticed what a large proportion of small branches has been removed from the unsprayed part. When the value of these branches is considered, the seriousness of this loss can be realized. The sprayed portion lost but a very small number of such twigs and is still in very good condition. The table below shows the numbers obtained in the spring and those removed in the fall. By the term "new" knots are meant those which appeared to have been produced by a new infection; "old" knots are those which apparently grew from the mycelium which had not been removed when the knots were cut in the spring.

April 25, 1894.

Unsprayed portions, knots removed	-	-	-	2002
Sprayed	"	"	"	1155

November 26, 1894.

Unsprayed portion, total number removed	3529—new knots	3466
Sprayed	" " " " 240 " "	165

The above figures are full of encouragement. They show, not that the black knot fungus has been held under absolute control, (and what fungous disease is,) but that it is susceptible to treatment. There was a large increase, nearly 57 per cent., in the number of knots cut in the fall from the unsprayed portion over those cut in the spring. Had the same proportionate increase taken place in the sprayed part, a supposition which must be allowed had no applications been made, the number of knots produced would have been within a fraction of 2000: Consequently, the 165 new knots should be compared with 2000, and not with 1155 as shown by the table. It must also be considered that this reduction took place in the face of circumstances which had been made as favorable for the spreading of disease as possible. The sprayed portion had been covered with knots during the first year's treatments. It was practically in contact with a large number of diseased plants. And finally, we are still in the dark as to the best time of making the application, for we do not know

with certainty when the infections take place, nor when the knot appears after infection has occurred. If this were known the matter would be considerably simplified, and still better results obtained. It would appear from the above that an orchard may be kept practically free from the knot if the trees are sprayed at the proper time. One or two treatments might be given before the blossoms open, and later applications probably need not be made oftener than is required to control the leaf-blight and the rotting of plums. If in addition to this the comparatively few knots which will undoubtedly appear be removed as soon as discovered, no grower need have much fear of this disease even though his trees be considerably exposed to infection from neighboring trees or thickets. The treatments which the above* experiment seems to justify me in recommending are as follows :

First. During the latter part of March or early in April.

Second. When the buds are beginning to swell.

Third. During the latter part of May, or as soon as the new knots begin to show their velvety coating.

Fourth. About two weeks after the third.

Fifth and Sixth. At intervals of two or three weeks after the fourth, but these two will probably not always be necessary.

The Bordeaux mixture may prove more valuable than other fungicides even in making the first applications, as it adheres better to the branches. It is probable that some of the above treatments may in time be dispensed with. Much will depend upon the season and upon the degree of infection to which the orchards are exposed.

It is scarcely necessary to add that all thickets, hedges, and useless trees which serve as breeding and distributing centers should be destroyed at the first opportunity. The species of *Prunus* mentioned on page 641 should be served in the same manner as useless cultivated plants, if they aid in the propagation of the fungus. In the end unceasing vigilance must bring its reward.

*It is unfortunate that other experiments begun at the same time and carried on in a manner similar to the above have failed to give results from the fact that no new knots formed upon either the sprayed or the unsprayed portions. The plum orchard of Geo. T. Powell, Ghent, N. Y., has been under treatment during two years, as well as other trees in the vicinity of Ithaca. All have failed to develop new knots. But the work will be continued and it is hoped to make other reports in the future.

SUMMARY.

1. The black-knot of plums and cherries was first troublesome in the Atlantic states. Page 637.
2. Its presence west of the Alleghany mountains seems to be due at least in part to plants introduced from the eastern states. Page 637.
3. The first swelling of the knot occasionally begins in the fall but is generally first noticeable in the spring. Page 638.
4. The young, growing knot is yellowish brown in color, but this color changes to black as the season advances. Page 638.
5. Knots most commonly form in the forks of young branches, at the union of the growths of two seasons, and upon the small spurs which commonly bear the fruit. Page 640.
6. The cause of the black-knot is a fungus, *Plowrightia morbosa*. Page 641.
7. The fungus produces from each knot one crop of spores during the early part of the season, and another during midwinter, after which the central portion of the knot dies. Page 641.
8. Black-knots are very generally infested by insects, but these are not the cause of such swellings. Page 641.
9. The time in which the spores produced by the fungus gain an entrance into the branches is not definitely known, but it seems probable that this occurs soon after the ripening of the spores. Page 642.
10. The manner in which the spores penetrate the outer tissues has not yet been observed; but the fact that the layer of cork is thinnest, or entirely wanting, in those places in which the greater number of knots are found leads to the conclusion that the fungus can penetrate the outer tissues at these points, but cannot enter at all places. Pages 643, 644.
11. Knots found upon old wood first obtained a foothold upon younger wood, from which they spread to the older parts. Page 646.
12. Many remedies for the black knot have been suggested but none have proved to be efficient. Page 647.
13. The most generally recommended preventive measure is to cut out the knots and destroy them. This work should be

done as soon as the knot is observed, and if well carried out it is an excellent method of exterminating the disease. Page 647.

14. Since fungicides have come into use, spraying for the black-knot has been recommended. Page 648.

15. The conclusions drawn by Maynard from the experiments of one season recorded by him were that "the number of warts was *very decidedly* less where treated with the copper mixture, than where untreated. * * * and we believe that the plum wart may be held in check by this remedy." Page 649.

16. A thicket of Morello cherries which had been treated during two seasons by this station produced only 165 new knots. Page 652.

17. From another portion of the same thicket which had not been treated there were cut 2002 knots on April 25, 1894. On November 26 of the same year this portion yielded 3466 new knots, an increase of nearly 58 per cent. Page 652.

18. Had the sprayed portion remained untreated it may be supposed that a similar increase would have taken place in this part, making the assumed number cut within a fraction of 2000. Page 652.

19. The reduction of the number of knots from 2000 to 165, considering the present state of our knowledge, and the conditions under which the experiment was carried on, are encouraging, and point to a final control of the disease. Page 652.

20. Some of the applications which now appear necessary for the control of the black knot are to be made when other diseases require treatment. This necessitates but little extra labor in spraying for the prevention of the knots. Page 653.

21. The spraying of plums and cherries to protect them from the black-knot fungus, as stated on page 653, can be carried on with profit in all sections where this disease threatens to interfere seriously with the profitable cultivation of these fruits.

E. G. LODEMAN.

FORMULAS.

BORDEAUX MIXTURE.

Copper sulphate	6 pounds
Quicklime.....	4 "
Water	40 gallons

Dissolve the copper sulphate by putting it in a bag of coarse cloth and hanging this in a vessel holding at least 4 gallons, so that it is just covered by the water. Use an earthen or *wooden vessel*. Slake the lime in an equal amount of water. Then mix the two and add enough water to make 40 gallons. It is then ready for immediate use. For rots, moulds, mildews, and all fungous diseases.

AMMONIACAL COPPER CARBONATE.

Copper carbonate.....	1 ounce
Ammonia.....	enough to dissolve the copper
Water.....	9 gallons

The copper carbonate is best dissolved in large bottles, where it will keep indefinitely, and it should be diluted with water as required. For same purpose as Bordeaux.

COPPER SULPHATE SOLUTION.

Copper Sulphate	1 pound
Water.....	15 gallons

Dissolve the copper sulphate in the water, when it is ready for use. *This should never be applied to foliage, but must be used before the buds break.* For peaches and nectarines use 24 gallons of water. For fungous diseases.

PARIS GREEN.

Paris green	1 pound
Water	250 gallons

If this mixture is to be used upon peach trees, 1 pound quicklime should be added. Repeated applications will injure most foliage, unless lime is added. *Paris green and bordeaux can be applied together with perfect safety.* The action of neither is weakened, and the Paris green loses all caustic properties. For insects which chew.

LONDON PURPLE.

This is used in the same proportion as Paris green, but as it is more caustic it should be applied with the lime, or with the Bordeaux mixture. Do not use it on peach or plum trees. For insects which chew.

HELLEBORE.

Fresh white hellebore	1 ounce
Water.....	3 gallons

Apply when thoroughly mixed. For insects which chew.

KEROSENE EMULSION.

Hard soap.....	$\frac{1}{2}$ pound
Boiling water.....	1 gallon
Kerosene.....	2 gallons

Dissolve the soap in the water, add the kerosene, and churn with a pump for 5-10 minutes. Dilute 10 to 15 times before applying. For insects which suck, cabbage worms, and all insects which have soft bodies.

30.677

N^o 7
C 896

Bulletin 82.

December, 1894.

Cornell University Agricultural Experiment Station.

VETERINARY DIVISION.

EXPERIMENTS

WITH

Tuberculin on Nontuberculous COWS.



By JAMES LAW.

PUBLISHED BY THE UNIVERSITY,
ITHACA, N. Y.
1894.

ORGANIZATION.

BOARD OF CONTROL:

THE TRUSTEES OF THE UNIVERSITY.

STATION COUNCIL.

President, JACOB GOULD SCHURMAN.

Hon. A. D. WHITE,	-	-	-	-	Trustee of the University.
Hon. JOHN B. DUTCHER,	-	-	-	-	President State Agricultural Society.
Professor I. P. ROBERTS,	-	-	-	-	Agriculture.
Professor G. C. CALDWELL,	-	-	-	-	Chemistry.
Professor JAMES LAW,	-	-	-	-	Veterinary Science
Professor A. N. PRENTISS,	-	-	-	-	Botany.
Professor J. H. COMSTOCK,	-	-	-	-	Entomology.
Professor L. H. BAILEY,	-	-	-	-	Horticulture.
Professor H. H. WING,	-	-	-	-	Dairy Husbandry.
Professor G. F. ATKINSON,	-	-	-	-	Cryptogamic Botany.

OFFICERS OF THE STATION.

I. P. ROBERTS,	-	-	-	-	Director.
E. L. WILLIAMS,	-	-	-	-	Treasurer.
H. W. SMITH,	-	-	-	-	Clerk.

ASSISTANTS.

M. V. SLINGERLAND,	-	-	-	-	Entomology.
GEO. C. WATSON,	-	-	-	-	Agriculture.
G. W. CAVANAUGH,	-	-	-	-	Chemistry.
E. G. LODEMAN,	-	-	-	-	Horticulture.
MICHAEL BARKER,	-	-	-	-	Horticulture.

Office of the Director, 20 Morrill Hall.

Those desiring this Bulletin sent to friends will please send us the names of the parties.

BULLETINS OF 1894.

62. The Japanese Plums in North America.
63. Co-operative Test of Sugar Beets.
64. On Certain Grass-Eating Insects.
65. Tuberculosis in Relation to Animal Industry and Public Health.
66. Test of Cream Separators.
67. Some Recent Chinese Vegetables.
68. The Cultivated Poplars.
69. Hints on the Planting of Orchards.
70. The Native Dwarf Cherries.
71. Apricot Growing in Western New York.
72. The Cultivation of Orchards.
73. Leaf Curl and Plum Pockets.
74. Impressions of the Peach Industry in Western New York.
75. Peach Yellows.
76. Some Grape Troubles of Western New York.
77. The Grafting of Grapes.
78. The Cabbage Root Maggot, with notes on the Onion Maggot and Allied Insects.
79. Varieties and Leaf-Blight of the Strawberry.
80. The Quince in Western New York.
81. Black-Knot of Plums and Cherries, and Methods of Treatment.
82. Experiments with Tuberculin on Nontuberculous Cows.

EXPERIMENTS WITH TUBERCULIN ON NON-TUBERCULOUS COWS.

On October 28th, 1894, the following cows were set apart for this experiment : two Holstein cows and one Jersey in full flow of milk, being about six weeks after calving, and two dry, farrow cows of common stock, one pointing to a Short-Horn ancestry and the other to a Devon one. Meanwhile observations on the milk of three other cows, two Holsteins and a Jersey, about the same length of time after calving, afforded a fair comparison between cows treated with tuberculin and others under similar conditions but without such treatment.

The first five cows to be tested with tuberculin, each received in proportion to its size, a full dose of tuberculin weekly and the temperatures were taken before the injection for the normal standard and about every two hours from about the ninth to about the twentieth hour after each tuberculin injection.

TEMPERATURE.

The tested animals were treated like the rest of the herd with the single exception, that in order to take the temperatures, they were tied up in the stalls for twenty-four hours on each occasion for testing, while the others were at liberty under an enclosed shed except when tied up for feeding and milking. The prolonged standing on hard boards, led on each occasion to congestion of the feet of the Holstein cow Mabel, which weighed 1455 lbs., but as this invariably took place under similar circumstances and apart from the injection of tuberculin, the slight rise of temperature on each occasion of testing is abundantly accounted for from the condition of the feet alone. This conclusion is further confirmed by the fact that, excepting in cases in which she was turned out in the afternoon to relieve her tender feet, the temperature went on steadily increasing to the last. This was notoriously the case in the three last tests of the series (Nov. 28th, Dec. 7th, Dec. 12th). On a previous occasion Mabel had been tested in

company with the entire herd and stood the test satisfactorily. Even in the present series of tests, this cow (with one exception) never rose more than two degrees above her initial temperature taken when that particular test was started, and she only rose nine-tenths of a degree above 102F.°, which may be set down as the normal standard temperature of a cow in full milk, highly fed and kept indoors. Taking into account the variations in healthy cattle from one time of the day to another, this rise of less than one degree above the general standard implies nothing.

The exceptional case was on Nov. 9th and 10th, when Mabel's temperature rose to 104°, and that of the Short-Horn grade to 104.3°. Taken by itself this test might have been misleading, but in connection with six other tests (in case of Mabel seven) made both before and after this, with the same dose of tuberculin and with no such resulting rise, it can safely be set down to accidental conditions. The real cause was not clearly made out, but it is probable that it was chargeable on exposure in a cold draught. Both cows stood on separate ranges close to the east door of the barn, through which the manure had to be forked out, and with a cold east wind entering by that door, and blowing on cattle that had been shut up in a warm building over night, a slight chill was to be expected.

The Jersey, *Daisy*, never rose above the normal standard of 102°, excepting in the first test and then only to 102.3°—too little to furnish even a suggestion of tuberculosis, no higher than we find in many well fed healthy cattle.

The Holstein, *Belva*, on two occasions rose to 102.5°, half a degree above the normal standard, but which is often attained to in health, and apart from the tuberculin test. Moreover on five other tests both before and after these she did not show a rise over 102° so that the less suspicion should arise from this insignificant elevation.

The *Devon grade cow* in different tests had her temperature elevated to 102° and on one occasion to 102.6°, a little more than half a degree above the normal, and which, as already said is found in the healthiest cows.

The *Short-Horn grade* had a fever temperature on one occasion apparently from a chill as already referred to. In her first test it

rose to 102.6° as did also the Devon grade on the same occasion. This may be explained partly by the fact that both had been driven a distance of seven miles the day previous causing much excitement, and followed by the excitement induced by coming into a new place and herd, and among new people.

One other point should be named as affecting the temperatures of all the test animals in the early forenoon and late afternoon. The whole herd was put in the barn for feeding and milking, from five to seven in the morning and from three to six in the afternoon, so that at these hours the place was crowded and the disturbance greater. Elevations of temperature of a degree and under occurring at such time, and as repeatedly seen in the tested animals are thus accounted for. Such elevations do not show the persistence and the slow gradations of rise and fall which we usually see in the rise caused by the tuberculin.

Taken all in all then there is nothing in the records of temperature that would indicate, either at the time of the test, or later, that the tuberculin had proved in any way inimical to the general health. Had the health been impaired by the repeated operation of the tuberculin it might have been expected that the constitutional disturbance would have been more distinctly marked in the later tests than in the earlier ones, and as no such tendency is observable it may be safely concluded that so far as illness can be indicated by a variation of temperature, test doses of tuberculin, in the absence of the bacillus, does not seem to produce any such illness in the healthy animal.

It has been alleged that the repeated use of tuberculin on animals slightly tuberculous, abolishes the tendency to reaction under the use of this agent. If this were true it would argue rather a curative than a malific action of the tuberculin, but in other experiments, I have found the second test made a week or more after the first to produce a no less marked reaction, so that this alleged tolerance need not be taken into account in the cases before us.

RESPIRATION AND PULSE.

As regards the record of the pulse and breathing given in the tables it is sufficient to say that they furnish no real indication of

a deviation from the most perfect health. In cattle pulse and breathing vary so widely under different conditions of the environment, digestive organs, exercise, etc., that it would take very much greater variations than those given in the tables to give true indications of disease.

MILK RECORD.

The milk record may be accepted as a more sensitive test of constitutional injury than temperature, breathing or pulse. It is also farther reaching than these other indications, as it involves a healthy exercise of all the bodily functions, and above all those of appetite, digestion, assimilation and secretion. An appreciable disturbance of the health at any one point will usually be manifested in this delicate balance in a variation of quantity or quality of the milk.

Belva. Taking the milk record of Belva as given in table VI, we find that the milk yield in the twenty hours following the injection of the tuberculin shows no constant nor striking difference from that of intervening days. The highest yield per day (42.25 lbs.) was on the fifth day succeeding the third injection of tuberculin, and on each of these five days the yield was from two to five pounds above the average. The lowest yield per day (31.5 lbs.) was on the fourth day after the first injection, while the preceding day's yield had been over a pound above the average, and the two days following the injection had been respectively two and three pounds below.

What is more significant is that the average yield of milk for the days following the seven injections of tuberculin is practically the same as the average yield for the whole 47 days included in the experiment. This may be stated clearly in tabular form thus:

Average of the seven days following the injections of tuberculin 37.257 lbs.

Average of the forty-seven days for which the milk record is given 37.247. The difference is 0.01., and is in favor of the days when the system was charged with the dose of tuberculin.

Daisy. The milk record of Daisy given in Table VII shows a great difference in the yield on different days, but no constant relation between the low daily yield and the days when the tuber-

culin was in the system. On the first, second, and fourth occasions in which the system was charged with the tuberculin the milk-yield was above the average, whereas on the third, fifth, sixth and seventh occasions it was below. The highest daily yield (22.25 lbs.) was on the day in the evening of which the first injection of tuberculin was made, and the second highest (21.5 lbs.), only three-fourths of a pound less, was on the day after that injection. The lowest daily yield (15 lbs.) was on the day when the last injection of tuberculin was in the system, and when besides the cow was in *heat*. This low yield was also reached on the day preceding the second last tuberculin injection (the ninth day after an injection), and also on the succeeding day when the system was charged with this second last injection. This low record could not be justly charged on the tuberculin injection seeing that it was already reached the day before that injection.

Daisy, like the rest of the herd, was falling off in milk during the experiment, and her average when charged with tuberculin suffers on account of her having reached her lowest mark on Dec. 7th on the evening on which a dose of tuberculin was given, and further, that on Dec. 13th the day of the last test, her milk shrank because she was in heat. Taking the seven tests the averages stand thus :

Average of the seven days following the injections of tuberculin 17.82 lbs.

Average of the forty-seven days for which the milk record is given, 18.26 lbs. This shows a difference of less than half a pound daily on the average against the tuberculin. If we leave out the last injection (Dec. 13th) when the cow was in heat, we find that the average yield per diem for the six days during which the cow was charged with tuberculin is slightly above the average for the whole forty-seven days of the trial.

Molly, Freda and Bertha. These cows were not injected with tuberculin and their milk records have been introduced to show that the daily oscillations in the yield and its progressive diminution in the main during the forty-seven days, was common to the whole herd and in no sense peculiar to the three cows that had been treated with tuberculin. The gradual failure can be seen in the tables. It may be more clearly shown by placing side by

side the general average for the first four weeks and the average for the last two weeks and five days.

Average for 1st twenty-eight days:

Belva lbs.	Molly lbs.	Freda lbs.	Daisy lbs.	Bertha lbs.
38.10	41.31	43.51	19.23	28.46

Average for last nineteen days:

Belva lbs.	Molly lbs.	Freda lbs.	Daisy lbs.	Bertha lbs.
36.00	42.87	40.51	16.76	26.13
-2.10	+1.56	-3.00	-2.47	-2.33

Molly has gone on improving but the others show a very decided falling off which is greater in the noninjected Freda than in the injected Daisy, and greater in the uninjected Bertha than in the injected Belva.

Oscillations. The variations above and below the general average for each animal injected and not injected with tuberculin will be very clearly seen by glancing at the tables giving the graphic illustration for two Holsteins and two Jerseys (Tables VIII and IX). In figures they may be shown as follows:

Belva. General average per day 37.247 lbs. Highest per day 42.25 lbs. Lowest per day 31.50 lbs.

Freda. General average per day 41.78 lbs. Highest per day 47.50 lbs. Lowest per day 34.50 lbs.

Daisy. General average per day 18.26 lbs. Highest per day 22.25 lbs. Lowest per day 15 lbs.

Bertha. General average per day 27.01 lbs. Highest per day 33.5 lbs. Lowest per day 23 lbs.

Molly. General average per day 41.19 lbs. Highest per day 48 lbs. Lowest per day 33.5 lbs.

The extremes it will be observed were actually greater for the cows that were not treated with tuberculin than for those so treated. Among the Holsteins *Belva* had a variation amounting to 10.75 lbs., *Freda* one of 13 lbs., and *Molly* one of 14.5 lbs. Among the Jerseys, *Daisy* had a variation of 7.25 lbs. and *Bertha* one of 10.5 lbs. Extreme variations in the yield of milk then cannot be charged on the action of a test dose of tuberculin injected into a healthy animal, nor of a series of such test doses administered at intervals of a week.

PERCENTAGE OF BUTTER-FATS IN THE MILK.

Before dismissing the milk it is desirable to consider how the ratio of butter-fats is affected by repeated test doses of tuberculin injected into a healthy animal. A study of the tables given below will fail to establish any connection between the presence of a test dose of the tuberculin in the animal body, and any increase or diminution of the fat in the milk. The Holstein *Belva* had her highest percentage of butter-fat (3.6) October 20th, ten days before the first injection of tuberculin. Her next highest record (3.4) was Dec. 8th while under the action of tuberculin. Her lowest record (2.8) was Dec. 1st, two days after the operation of a dose of tuberculin. Her variation (0.8) is only a little more than that of the untreated cow *Freda* (0.6), and only about half that of *Molly* (1.5). The Jersey *Daisy* also made her highest percentage (5.6) October 20th and her lowest (4.8) December 8th when under the action of tuberculin. But she made her second highest (5.55) Nov. 10th when under tuberculin and an equal record Nov. 17th two days after the operation of a dose of tuberculin. Her greatest variation was 0.7 per cent., whereas, that of the untreated cow *Bertha*, was 1.15 per cent.

There is therefore no change in the percentage of butter-fats sufficient to indicate any disease or ill-health as the result of the administration of repeated test doses of tuberculin.

EFFECT ON BODY WEIGHT.

The weight of the animals varied so little during the experiment that it might be said to have remained stationary. The record is as follows:

	October 30th.	Dec. 1st.	Dec. 13th.	Jan. 5th, 1895.
<i>Belva</i> , 1264 lbs.,		1305 lbs.,		1405 lbs.
<i>Mabel</i> , 1455 "		1540 "		1570 "
<i>Daisy</i> , 945 "		950 "		965 "
Short Grade Horn,		1020 "	1020 lbs.,	1025 "
Grade Devon,		895 "	915 "	910 "

Considering that a variation of 50 lbs. in the weight of a cow may occur in a few hours according as it is taken before or after feeding and watering or milking, there may be said to have been no change excepting in the case of the two Holsteins in which

there is shown a gain of 141 lbs. and 115 respectively. It is worthy of notice that the last weighing, which makes the highest record was made three to four hours after the morning feeding, and (in the case of the three first cows) of the morning milking. The two dry cows had been watered but had not been fed on the morning of the last weighing as they were just about to be killed.

It may be concluded that the repeated test doses of tuberculin had in no injurious way affected assimilation and that, in the two Holstein cows, it had not prevented a perceptible improvement in this respect.

POST MORTEM EXAMINATIONS.

To complete the record the two farrow cows were killed Dec. 5th, 1894, and subjected to careful necropsy. In the main the viscera were sound. The shorthorn grade had pus in each of the left quarters of the mammary gland in the milk sinus, the walls of which were red and thickened. When stained and placed under the microscope, the pus showed numerous cocci but no bacilli.

As is usual in old cows, the groups of lymphatic glands in the intermaxillary and pharyngeal regions, in the chest, the abdomen, the subcutaneous and intermuscular regions were pigmented of a dark grayish color, varying at different points but in no case showing molecular degeneration, coagulation-necrosis (casseeation) nor even perceptible congestion. In the shorthorn grade the lymphatic glands behind the diseased mammae were considerably enlarged.

EXPERIMENTS AT THE U. S. BUREAU OF ANIMAL INDUSTRY.

In the "investigations concerning bovine tuberculosis 1894," Dr. Schweinitz records the effect on the milk of two healthy cows one of which received one dose and the other three successive doses of tuberculin. The dose on each occasion was 2 cc. for each cow and as they were common stock it may be inferred that it was a full dose considering the probable weight of the animals. Of variations in temperature it is enough to say that there was no more than would occur in the best of health. The analysis of

the milk is given in table XII from which it will be seen that the single test of cow No. 113 there was a slight reduction of the total solids, and of the different constituents such as sugar, albuminoids and fat. The second cow, No. 217, tested three times under tuberculin and once on five successive days without tuberculin gives a more trustworthy basis for estimating the effect of that agent. It will be observed that on April 1st under the tuberculin there was a slight decrease of the total solids (0.45), on April 13th under tuberculin a still larger decrease (1.26), but on June 5th under tuberculin there was an increase (1.01). On June 11th to 15th without tuberculin there was a variation in the total solids of 1.99.

Then as to the milk sugar, 217 showed a percentage reduction of 0.1 April 1st under tuberculin and of .61 April 13th, but no change whatever June 5th though again under tuberculin and no change June 11th to 15th without tuberculin.

Of albuminoids 217 showed a percentage reduction of .07 April 1st under tuberculin, but an increase of .13 April 13th and .61 June 5th. In the absence of tuberculin it showed a variation of .42 June 11th to 15th.

In fat, No. 113 had a decrease in her single test, while 217 had an increase in all cases under tuberculin .31 April 1st, .13 April 13th, and .86 June 5th. In the entire absence of tuberculin June 11th to 15th she showed a variation of .51.

With such a testimony it would be disingenuous to claim, any constant or appreciable variation as the result of the injection of a test dose of tuberculin, into a healthy animal even if such dose were repeated several times. So far as there is evidence before us, everything points to the harmlessness of a single test dose on a sound animal system.

JAMES LAW.

Cornell University, Ithaca, N. Y.,
January 8th, 1895.

TABLE I.

ACTION OF TUBERCULIN ON HOLSTEIN COW BELVA IN FULL MILK.

Before Injection.							After Injection.							
Date 1894.	Norm. Temp.	Resp.	Pulse.	Tuber- culin Dose.	Hour.		Temp.	Resp.	Pulse.	Hour.	Temp.	Resp.	Pulse.	Hour.
Oct. 30-31	Deg. 101	..	..	30m	P. M. 9:45		Deg. 102.1	..	..	A. M. 6:45	Deg. 101.5	30	72	A. M. 9:15
Nov. 9-10	101.3	..	..	30m	P. M. 10:00		101.8	16	..	A. M. 7:00	100.2	13	..	A. M. 9:30
14-15	101	15	..	30m	P. M. 10:30		101.6	18	..	A. M. 7:30	100.8	16	..	A. M. 9:30
23	101	24	..	30m	A. M. 7:00		101.5	16	..	P. M. 2:30	101.6	21	..	P. M. 4:00
28-29	100	13	..	30m	P. M. 10:15		101.8	18	..	A. M. 7:00	100.5	14	..	A. M. 9:15
Dec. 7-8	101.5	20	..	30m	10:30		101.9	21	72	7:30	100.4	12	72	A. M. 10:00
12-13	100.8	20	63	30m	10:30		101.5	16	..	7:15	101.4	16	..	10:15

TABLE II.

ACTION OF TUBERCULIN ON HOLSTEIN COW MABEL IN FULL MILK.

Before injection.							After injection.							
Date 1894	Norm. Temp.	Resp.	Pulse.	Tuber- culin Dose.	Hour.		Temp.	Resp.	Pulse.	Hour.	Temp.	Resp.	Pulse.	Hour.
Oct. 30-31	Deg. 100.9	..	..	31m	P. M. 9:45		Deg. 100.9	..	..	A. M. 9:45	Deg. 102.6	28	..	A. M. 9:15
Nov. 9-10	101.4	..	..	31m	P. M. 10:00		102.8	18	..	A. M. 7:00	104	22	..	9:30
14-15	101	23	..	31m	P. M. 10:30		101.5	18	..	6:46	101.9	16	..	A. M. 8:30
23	101.9	22	..	31m	A. M. 7:00		102	18	..	P. M. 2:30	102.5	21	..	P. M. 4:00
28-29	101.5	14	..	31m	P. M. 10:15		102	21	..	A. M. 7:00	100.9	16	..	A. M. 9:15
Dec. 7-8	101.4	18	..	31m	10:30		102	20	..	A. M. 7:30	101.6	24	..	A. M. 10:00
12-13	102	24	63	31m	10:30		102.6	18	..	A. M. 7:15	102.6	24	..	A. M. 10:15

TABLE III.

ACTION OF TUBERCULIN ON JERSEY COW DAISY; CALVED SEPT. 12, 1894.

Before Injection.							After injection.							
Date 1894.	Norm. Temp.	Resp.	Pulse.	Tuber- culin Dose.	Hour.		Temp.	Resp.	Pulse.	Hour.	Temp.	Res.	Pulse.	Hour.
Oct. 30-31	Deg. 101	..	..	26m	P. M. 9:45		Deg. 101.8	..	..	A. M. 6:45	Deg. 101.5	30	72	A. M. 9:15
Nov. 9-10	101	..	..	26m	P. M. 10:00		101.6	24	72	A. M. 7:00	100.8	12	..	9:30
14-15	100.8	21	..	26m	P. M. 10:30		101.8	23	..	6:45	100.9	9	..	A. M. 9:30
22-23	101	18	72	26m	P. M. 10:20		101.5	21	..	A. M. 7:00	101	15	66	A. M. 9:30
28-29	101	15	..	26m	P. M. 10:15		101.7	15	..	A. M. 7:00	100.5	16	..	A. M. 9:15
Dec. 7-8	101.5	27	..	26m	10:30		101.8	30	54	A. M. 7:30	100.9	18	62	A. M. 10:00
12-13	101.3	29	66	26m	10:30		101.7	16	..	A. M. 7:15	100.3	18	60	10:15

EXPERIMENTS WITH TUBERCULIN.

669

TABLE I.
CALVED SEPTEMBER 16TH, 1894.

AFTER INJECTION—

Temp.	Resp.	Pulse.	Hour.	Temp.	Resp.	Pulse.	Hour.	Temp.	Resp.	Pulse.	Hour.	Temp.	Resp.	Hour.
Deg.			A. M.	Deg.			P. M.	Deg.			P. M.	Deg.		P. M.
101.5	30	60	11:25	102.3	15		1:45	101.9	20	69	4:15	102		6:45
							P. M.				P. M.			
101.5			11:30	101.7	17		2:00	101.4	18		4:00	101	20	6:30
							P. M.				P. M.			P. M.
101.2	16		11:30	101.5	15		1:00	101.8	13		3:00	102.5	20	5:00
			P. M.				P. M.							
101.5	17		7:00	101	15		10:00							
			A. M.				P. M.				P. M.			
101	16		11:45	101.9	20	60	2:00	102.5	14		4:00			
			P. M.				P. M.				P. M.			
100.9	20	60	12:10	101.8	16	66	3:00	101.6	20		4:45			
			P. M.				P. M.				P. M.			
101.3	16	60	12:15	101.6	18		2:15	101.7			4:30	Was in heat Dec. 11th		

TABLE II.
CALVED OCTOBER, 1894.

AFTER INJECTION—

Temp.	Resp.	Pulse.	Hour.	Temp.	Resp.	Pulse.	Hour.	Temp.	Resp.	Pulse.	Hour.	Temp.	Resp.	Hour.
Deg.			A. M.	Deg.			P. M.	Deg.			P. M.	Deg.		P. M.
102.9	42	72	11:25	102.6	32		1:45	102.2	26	72	4:15	101.5		6:45
							P. M.				P. M.			
102.8	26		11:45	102.6	18		2:00	101.7	22		4:00	101.5	19	6:30
							P. M.				P. M.			P. M.
101.8	18		11:15	102	18		1:00	102.2	21		3:00	102	20	5:00
			P. M.				P. M.							
102.2	24		7:00	102	22		10:00							
			A. M.				P. M.				P. M.			P. M.
101.9	14		11:45	101.7	14		2:00	102.2	18		4:00	102.5	24	5:20
			P. M.				P. M.				P. M.			
102.3	20		12:10	102.8	16		3:00	102.6	12		4:45	P. M. Feet sore from standing on boards.		
			P. M.				P. M.							
102.9	16	60	12:15	103.2	31		2:15	103			4:30			

TABLE III.

AFTER INJECTION—

Temp.	Resp.	Pulse.	Hour.	Temp.	Resp.	Pulse.	Hour.	Temp.	Resp.	Pulse.	Hour.	Temp.	Resp.	Hour.
Deg.			A. M.	Deg.			P. M.	Deg.			P. M.	Deg.		P. M.
101.5	30	60	11:25	102.3	15		1:45	101.9	20	69	4:15	102		6:45
							P. M.				P. M.			
101.2	17		11:45	101.7	20		2:00	101.8	22		4:00	101.2	18	6:30
							P. M.				P. M.			P. M.
101	16		11:15	101	17		1:00	101.2	22		3:00	101.7	20	5:00
			A. M.				P. M.				P. M.			P. M.
100.8	15		11:30	101.3	15		2:30	101.5	17		4:00	101.3	24	7:00
							P. M.					101.4		10:10
			A. M.				P. M.							P. M.
100.5	18		11:45	101.2	14	48	2:00	101	14		3:00	101.5		5:20
			P. M.				P. M.				P. M.			
101.3	22	68	12:10	101	20	60	3:00	101.8	16		4:45			
			P. M.				P. M.							
100.7	30	60	12:15	101.8	30		2:15	101.8			4:30	In heat : took bull.		

TABLE IV.

ACTION OF TUBERCULIN ON GRADE SHORT-HORN COW : NEARLY DRY :

Before injection.							After injection.							
Date 1894.	Norm. Temp.	Resp.	Pulse.	Tuber- culin Dose.	Hour.		Temp.	Resp.	Pulse.	Hour.	Temp.	Resp.	Pulse.	Hour.
Nov. 3	Deg. 100.3	. .	. .	28m	A. M. 6:30		Deg. 101.2	20	. .	P. M. 2:00	Deg. 102.3	17	. .	P. M. 4:00
9-10	102.7	. .	. .	29m	P. M. 10:00		104.3	30	72	A. M. 7:00	103.7	22	. .	P. M. 9:15
14-15	101	16	54	28m	P. M. 10:30		101	20	48	P. M. 7:00	101.7	20	56	A. M. 9:30
22-23	100.6	21	. .	28m	P. M. 10:20		100.8	25	. .	P. M. 7:00	102	25	54	P. M. 9:30
28-29	101	16	43	28m	P. M. 10:15		101.3	20	44	P. M. 7:00	102	16	48	A. M. 9:15
Dec. 7-8	101.5	22	48	28m	P. M. 10:30		100.5	23	50	A. M. 7:30	101	22	42	P. M. 10:00
12-13	101.6	30	60	29m	P. M. 10:30		101.9	18	. .	A. M. 7:15	102.3	17	52	A. M. 10:15

TABLE V.

ACTION OF TUBERCULIN ON GRADE DEVON COW : DRY : FARROW.

Before injection.							After injection.							
Date 1894.	Norm. Temp.	Resp.	Pulse.	Tuber- culin Dose.	Hour.		Temp.	Resp.	Pulse.	Hour.	Temp.	Resp.	Pulse.	Hour.
Nov. 3	Deg. 101.5	. .	. .	28	A. M. 6:30		Deg. 101	18	. .	P. M. 2:00	Deg. 102.3	17	. .	P. M. 4:00
9-10	101.7	. .	. .	27	P. M. 10:00		101.8	24	60	A. M. 7:00	102.1	12	. .	P. M. 9:15
14-15	101.5	18	62	26	P. M. 10:30		102.2	22	48	P. M. 7:00	102.2	18	50	A. M. 9:30
22-23	100.2	14	. .	27	P. M. 10:20		101	15	. .	P. M. 7:00	102	11	48	P. M. 9:30
28-29	101.2	11	50	27	P. M. 10:15		102	16	42	P. M. 7:00	101.2	11	42	A. M. 9:15
Dec. 7-8	101.5	16	60	27	P. M. 10:30		101.8	23	60	A. M. 7:30	102.3	24	60	P. M. 10:00
12-13	101	13	48	27	P. M. 10:30		101.7	14	43	A. M. 7:15	101.1	17	48	A. M. 10:15

671

FARROW. AFTER INJECTION.—

[illegible]

AFTER INJECTION.—

[illegible]

TABLE VI.

MILK RECORD OF BELVA, FOR THE PERIOD OF THE TUBERCULIN TEST, AND OF TWO OTHER HOLSTEIN COWS IN SIMILAR CONDITIONS APART FROM THE TEST.

	BELVA. Calved Sept. 16th. Lbs.	MOLLY. Calved Oct. 4th. Lbs.	FREDA. Calved Aug. 28th. Lbs.
Oct. 28th,	40.5	39.5	44.5
" 29th,	39.75	42.25	44.5
" 30th,	40.5	42.25	44.5
" 31st,	35 *	37.5	45.25
Nov. 1st,	34.5	40.75	36
" 2nd,	38.5	42.5	41.75
" 3rd,	31.5	34.75	40.25
" 4th,	37	34.75	42.75
" 5th,	32	33.5	40.5
" 6th,	36	35.75	41.5
" 7th,	35.75	37	45.75
" 8th,	38.25	40.5	47.5
" 9th,	38	40.5	46
" 10th,	38	41.25	43.5
" 11th,	39	41.5	42.5
" 12th,	36.75	40.75	41.75
" 13th,	41.25	45.5	45
" 14th,	41.5	42.25	47
" 15th,	41.25*	46.5	45.75
" 16th,	39.5	43.5	42
" 17th,	40.75	45	43.75
" 18th,	41	45	43.25
" 19th,	42.25	48	43.25
" 20th,	38	42.5	42
" 21st,	37.75	43	41.5
" 22nd,	37.25	44.5	37 served
" 23rd,	38.5 *	43.5	37.75
" 24th,	37.75	40	37.5
" 25th,	36.25	38	34.5
" 26th,	34.25	38.5	35.25
" 27th,	36.25	41	36
" 28th,	35	41	36.25
" 29th,	35 *	41	39
" 30th,	34.75	41.5 served	41.25
Dec. 1st,	35.5	42.5	42.25
" 2nd,	33.75	42	41.5
" 3rd,	35.75	41.5	42.25
" 4th,	34.75	38.75	40
" 5th,	38.25	42.25	43.75
" 6th,	39	42.75	44.75
" 7th,	38.5	43.75	45
" 8th,	34.75*	43.25	42.75
" 9th,	37.25	43.25	42
" 10th,	37.25	41.25	41.5
" 11th,	35.75	41.5	40
" 12th,	34.25	42.25	40.5
" 13th,	37.25*	43	39.5

* Indicates the 20 hours following the different tuberculin injections.

TABLE VII.

MILK RECORD OF DAISY, DURING THE PERIOD OF THE TUBERCULIN TEST, AND OF ANOTHER JERSEY COW UNDER SIMILAR CONDITIONS APART FROM THE TEST.

DAISY.		BERTHA.		DAISY.		BERTHA.	
Calved	Sept. 12th.	Calved	Sept. 17th.	Calved	Sept. 12th.	Calved	Sept. 17th.
	Lbs.		Lbs.		Lbs.		Lbs.
Oct.	28, 20.75		29.25	Nov.	21, 18		30
"	29, 20.75		27.75	"	22, 19.25		27
"	30, 22.25		29.75	"	23, 18.5*		26.5
"	31, 21.5*		26	"	24, 17		25.5
Nov.	1, 19		27.75	"	25, 17		26
"	2, 20.25		27.25	"	26, 18		23.5
"	3, 19		26	"	27, 17		23 served
"	4, 20.5		26.75	"	28, 19		23
"	5, 17.25		24.75	"	29, 18*		24.25
"	6, 19.75		24	"	30, 17		23
"	7, 17.75		26.25	Dec.	1, 17		24.5
"	8, 19.5		30.25	"	2, 19		26
"	9, 21		30.25	"	3, 16		25.5
"	10, 19.25*		28	"	4, 17		24
"	11, 17		27.5	"	5, 16		26.5
"	12, 18.5		28.5	"	6, 17		26
"	13, 20		29.75	"	7, 15		28.25
"	14, 19		27.75	"	8, 15*		27.5
"	15, 17.5*		29	"	9, 17		27
"	16, 19.75		32.5	"	10, 15.75		24.25
"	17, 18.25		33.5	"	11, 16.75		26.25
"	18, 19.5		30	"	12, 17		27
"	19, 17.5		30.75	"	13, 15* served		26.75
"	20, 20.5		25.5				

* Tuberculin in system, the day following injection.

TABLE VIII.

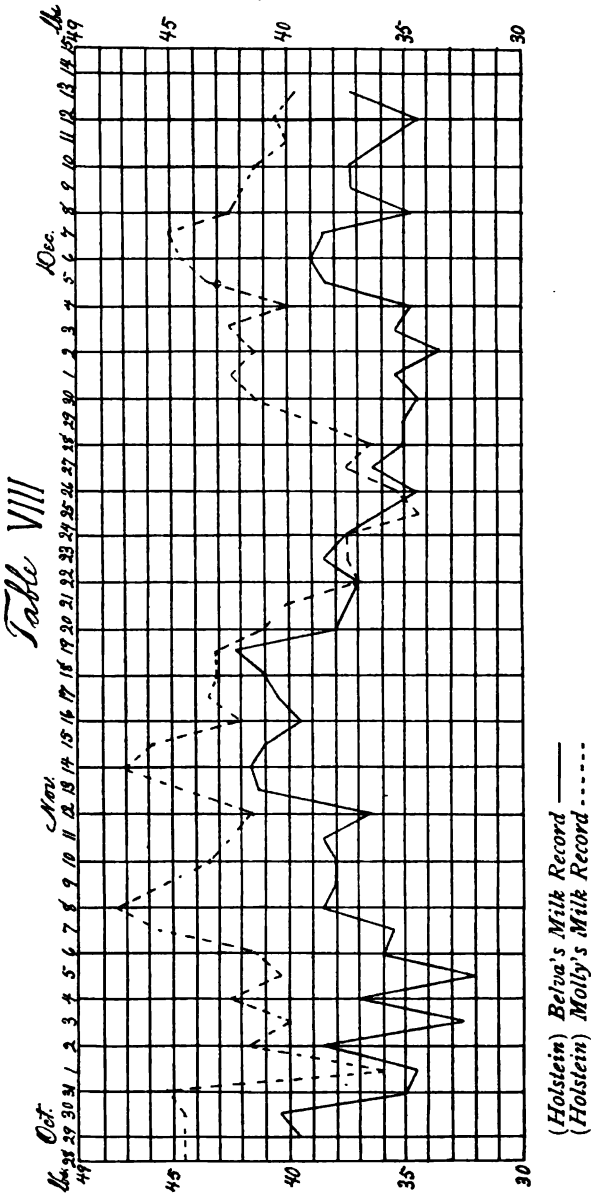


TABLE IX.

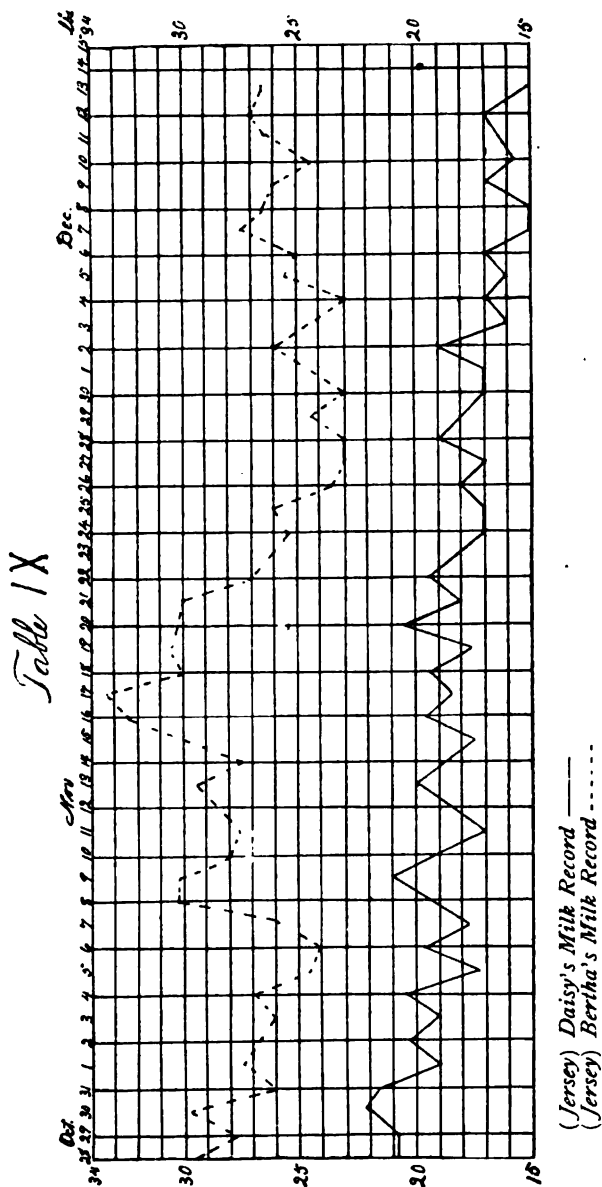


TABLE X.

PERCENTAGE OF BUTTER-FATS IN MILK OF BELVA DURING EXPERIMENT ;
ALSO IN HOLSTEIN COWS MOLLY AND FRED A NOT INJECTED.

		BELVA.	MOLLY.	FREDA.	
Oct.	20,	3.6 %	4.9 %	3.2 %	
"	27,	2.85 %	3.85 %	3.5 %	Three days before 1st injection of tuberculin.
Nov.	3,	3.2 %	4.25 %	3.55 %	Three days after tuberculin injection.
"	10,	3.2 %	3.8 %	3.35 %	Under tuberculin. Injected night before.
"	17,	3.3 %	3.75 %	3 %	Two days after tuberculin.
"	24,	2.9 %	3.65 %	3.3 %	One day after tuberculin.
Dec.	1,	2.8 %	3.95 %	2.95 %	Two days after tuberculin.
"	8,	3.4 %	3.4 %	3.1 %	Under tuberculin. Injected night before.

TABLE XI.

PERCENTAGE OF BUTTER-FATS IN MILK OF DAISY DURING TUBERCULIN
EXPERIMENT; ALSO OF JERSEY COW BERTHA NOT INJECTED.

		DAISY.	BERTHA.	
Oct.	13,	5.1 %	4.8 %	
"	20,	5.6 %	4.45 %	
"	27,	5.1 %	5.05 %	Three days before 1st injection of tuberculin.
Nov.	3,	5.3 %	5.05 %	Three days after tuberculin injection.
"	10,	5.5 %	5.3 %	Under tuberculin. Injected night before.
"	17,	5.5 %	5.4 %	Two days after tuberculin.
"	24,	5.4 %	4.25 %	One day after tuberculin.
Dec.	1,	5.05 %	5.1 %	Two days after tuberculin.
"	8,	4.9 %	4.85 %	Under tuberculin. Injected night before.

TABLE XII.

PERCENTAGE VARIATION IN THE CONSTITUENTS OF THE MILK OF HEALTHY
COWS UNDER A TEST DOSE OF TUBERCULIN.

Animal.	Date.	Total solids.	Sugar.	Albumi- noids.	Fat.	Ash in milk.	Acidity. Lactic acid.	
No. 113,	Mar. 31,	11.01	4.17	3.26	2.54	.775		Before injection
"	113, Apr. 1,	10.69	3.84	3.20	1.52	.696		After "
"	217, Mar. 31,	10.83	4.17	2.96	2.23	.723		Before "
"	217, Apr. 1,	10.38	4.16	2.89	2.54	.700		After "
"	217, " 12,	11.03	4.17	1.26	2.56	.681		Before "
"	217, " 13,	9.77	3.57	1.39	1.53	.727		After "
"	217, May 31,	12.03	4.16	2.82	2.43	.711		Before "
"	217, Jun. 1,	10.25	4.16	2.29	1.27	.666		" "
"	217, " 5,	11.26	4.16	2.70	2.03	.688	.176	After "
"	217, " 11,	11.97	4.16	4.17	2.03	.590		No "
"	217, " 12,	10.82	4.16	3.83	1.52	.692		" "
"	217, " 13,	11.30	4.16	3.97	2.02	.751		" "
"	217, " 15,	11.62	4.16	4.25	2.03	.767		" "

N7
C89b

Supl

Bulletin 83.

December, 1894.

Cornell University Agricultural Experiment Station.

ENTOMOLOGICAL DIVISION.

A PLUM SCALE

IN WESTERN NEW YORK.



By M. V. SLINGERLAND.

PUBLISHED BY THE UNIVERSITY,
ITHACA, N. Y.
1894.

ORGANIZATION.

BOARD OF CONTROL:

THE TRUSTEES OF THE UNIVERSITY.

STATION COUNCIL.

President, JACOB GOULD SCHURMAN.

Hon. A. D. WHITE,	-	-	-	-	Trustee of the University.
Hon. JOHN B. DUTCHER,	-	-	-	-	President State Agricultural Society
Professor I. P. ROBERTS,	-	-	-	-	Agriculture.
Professor G. C. CALDWELL,	-	-	-	-	Chemistry.
Professor JAMES LAW,	-	-	-	-	Veterinary Science.
Professor A. N. PRENTISS,	-	-	-	-	Botany.
Professor J. H. COMSTOCK,	-	-	-	-	Entomology.
Professor L. H. BAILEY,	-	-	-	-	Horticulture.
Professor H. H. WING,	-	-	-	-	Dairy Husbandry.
Professor G. F. ATKINSON,	-	-	-	-	Cryptogamic Botany.

OFFICERS OF THE STATION.

I. P. ROBERTS,	-	-	-	-	Director.
E. L. WILLIAMS,	-	-	-	-	Treasurer.
H. W. SMITH,	-	-	-	-	Clerk.

ASSISTANTS.

M. V. SLINGERLAND,	-	-	-	-	Entomology.
GEO. C. WATSON,	-	-	-	-	Agriculture.
G. W. CAVANAUGH,	-	-	-	-	Chemistry.
E. G. LODEMAN,	-	-	-	-	Horticulture.
MICHAEL BARKER,	-	-	-	-	Horticulture.

Office of the Director, 20 Morrill Hall.

Those desiring this Bulletin sent to friends will please send us the names of the parties.

BULLETINS OF 1894.

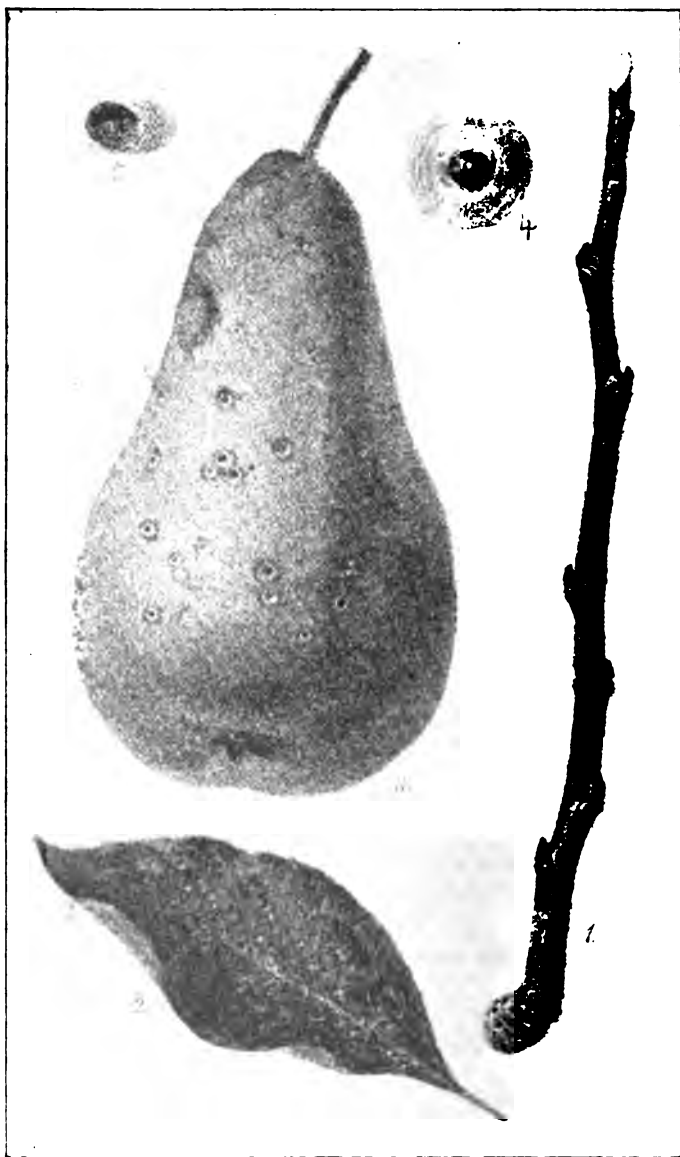
62. The Japanese Plums in North America.
63. Co-operative Test of Sugar Beets.
64. On Certain Grass-Eating Insects.
65. Tuberculosis in Relation to Animal Industry and Public Health.
66. Test of Cream Separators.
67. Some Recent Chinese Vegetables.
68. The Cultivated Poplars.
69. Hints on the Planting of Orchards.
70. The Native Dwarf Cherries.
71. Apricot Growing in Western New York.
72. The Cultivation of Orchards.
73. Leaf Curl and Plum Pockets.
74. Impressions of the Peach Industry in Western New York.
75. Peach Yellows.
76. Some Grape Troubles of Western New York.
77. The Grafting of Grapes.
78. The Cabbage Root Maggot, with notes on the Onion Maggot and Allied Insects.
79. Varieties and Leaf-Blight of the Strawberry.
80. The Quince in Western New York.
81. Black-Knot of Plums and Cherries, and Methods of Treatment.
82. Experiments with Tuberculin on Nontuberculous Cows.
83. A Plum Scale in Western New York.

CORNELL UNIVERSITY, ITHACA, N. Y., Dec. 20, 1894.

THE HONORABLE COMMISSIONER OF AGRICULTURE, ALBANY.

Sir: Probably the most serious enemy which has appeared in New York orchards in many years is a scale insect, which attacks plums and some other trees. It is not known how long the insect has been a resident of the state, but it has not attracted the attention of orchardists until within the last year or two; yet even now it threatens the entire destruction of thousands of trees in the counties of Niagara, Monroe and Ontario. The full life history of the insect is not yet understood and its scientific name is not determined; but Mr. Slingerland has made a careful study of it during the summer and has discovered enough of its characteristics to enable him to give competent advice for its destruction. It can be destroyed by persistent spraying between now and spring. This bulletin is essentially a report of progress in the study of this scale, and in order to aid the reader in distinguishing it from the San José scale, which has recently appeared in the state, an illustration of the latter insect is inserted. The bulletin is approved by Professor Comstock. The whole account is submitted as a bulletin in compliance with Section 87, Chapter 675, of the laws of 1894.

L. H. BAILEY.



THE SAN JOSÉ SCALE.

1, Infested branch ; 2, infested leaf ; 3, pear, bearing a few of the scales ; 4, female scale—enlarged ; 5, male scale—enlarged.
 (Adapted from report of W. G. Klee, 3d Rept., Cal. Bd. Hort.) Inserted for comparison with the western New York plum scale, described in the following pages.

A PLUM SCALE.

Lecanium sp.

Order HEMIPTERA; family COCCIDÆ.

Heretofore, the scale insects have played but a very small part in the havoc annually resulting from the attacks of insect pests in the northern and eastern parts of the United States. In the extreme western (California) and southern (Florida and Louisiana) states, however, most of the energy expended by fruit growers in combating their foes has to be directed against this class of insects, which there take first rank as pests. But, during the past year, two scale insects appeared in such numbers in some of the northern and eastern states as to greatly alarm fruit growers. One of these is the dreaded San José Scale (*Aspidiotus perniciosus*) of California, which has recently appeared in our state, especially on Long Island. Figures of this pernicious scale are given on the preceding page to familiarize fruit growers with its appearance, and also more especially for comparison with those of another scale which now threatens the plum industry. This latter scale has doubtless been present in eastern plum orchards for years, apparently awaiting certain conditions that seem at last to have occurred in certain localities, but more especially in western New York.

The past year, several of the largest and finest plum orchards in our state have suffered severely from this plum scale. In one orchard of over 2000 trees, one fourth of the immense crop was not worth picking and most of the remainder was badly damaged. But still more alarming than this is the fact that there are more than 50,000 of the best plum trees in western New York, which, at the present moment, are harboring millions of these scales; and unless these are destroyed this winter or in the spring, they will literally overrun these trees with such dire results as we scarcely dare predict. In short, the indications are that if this pest is allowed to begin work in full force in the spring of 1895, it will soon ruin some of the finest plum orchards in the state.

Our study of this new pest has not progressed far enough to enable us to present a complete account, but fortunately the work has reached a stage when we can confidently recommend an effective method for checking the insect before another season opens. We feel that the gravity of the situation demands that the fruit growers be made acquainted at once with the facts already learned.

THE INSECT'S APPEARANCE.

Fortunately, the larger, conspicuous, brown, dead scale or shell of the mature female insect is present on infested trees during the whole year, thus enabling fruit growers to tell at any time whether the pest is in their orchards or not. The illustration on the front of this bulletin shows many of these dead scales natural size as they appear on the branches. They are very conspicuous objects, as the figure shows, and may be easily found and recognized wherever they occur. They remind one of small halved peas colored dark brown and stuck on the branches. Beneath these dead scales the bark presents a white scar of the exact shape of the outline of the scale; these spots remain white for a long time after the scale is removed.

In April and May the living female insects resemble the dead scales shown in the figure on the title page, but they are soft to the touch and often striped with yellow. In June, after egg-laying has ceased, they become firm, smoother, lose their yellow markings, and are then simply a dark brown shell. If this shell be then turned over, it will be found full of the minute white eggs of the pest. After July 15, the dead scales contain nothing but a white dust consisting of the empty egg shells. Although these brown shell-like remains of the mother insect persist on the branches throughout the season, or even for a year or more, they are no longer a menace to the tree. They occur most numerous on the undersides of the branches of the preceding one or two year's growth.

Should a fruit grower find these large dead brown scales one half as thick on his plum trees as they are shown in the figure, he may be quite sure that there is also an alarming crop of the young scales now in hibernation in similar localities on the trees.

When the large shells are found, closely examine the bark in their vicinity for minute, very flat, spindle-shaped, dark brown scales. Many of these are shown, natural size, on the plum branch in figure 1; when these young scales occur as numerously as shown in this figure, they are easily seen in the winter. It is this stage of the insect that now portends danger to some of the best orchards in the state. They are to be found snugly tucked away into almost every crevice on the trees from the trunk near the ground to the topmost twig. How they got there, and what they will do in the spring (they are now doing no harm) is discussed further on under the life history of the pest. The male insect is also discussed under the same heading.



FIG. 1.—Plum branch containing many young scales in hibernation near the large mother-shells; and plum leaves with many of the young scales along the veins, as they appear in summer. All natural size.

ITS NAME.

This plum scale is allied to the well-known Mealy Bugs on green house plants, to the Oyster-shell Bark-louse so common on some unhealthy apple trees here in the east, and to the very destructive San José Scale recently introduced into our state. However, the pest belongs to a different group of the scale insects known as the Lecaniums; several species of Lecaniums are serious pests in California orchards. As this difficult group has received compara-

tively little attention from systematic workers in etymology, it is not easy to definitely decide whether a *Lecanium* found on a certain plant is new to science or is a species which received a name years before. This plum scale has been in the hands of experts for several months, but different opinions still prevail as to what it shall be called. It is probably some European species described a half century or more ago.*

THE DISTRIBUTION, DESTRUCTIVENESS, AND PAST HISTORY OF THE INSECT.

The present uncertainty regarding the name of this Plum Scale makes it impossible to draw any definite conclusions about its history, distribution, or destructiveness previous to 1894. However, we believe it is an European insect which has been present in eastern plum orchards for many years. A careful examination of several orchards which were apparently free from the insect, revealed the scales scattered here and there on the trees, sometimes not more than one or two on a tree. Certain conditions, perhaps climatic or possibly the presence of many active enemies, seem to have thus far held the insect in check in a majority of orchards. While in other localities, especially in the counties of Niagara, Monroe, and Ontario in our state, certain unknown conditions have favored the increase of the pest during the past three

* Mr. T. D. A. Cockerell, who has given considerable study to this group of scales, concludes that the pest is the Butternut or Walnut Scale (*Lecanium juglandis* Bouché) with which Dr. Fitch's *L. juglandifex* is synonymous ("The Entomologist" for December, 1894). There is a *Lecanium*, which is quite common on butternut in our state, that is very closely allied to if not identical with, this Plum Scale; but no butternut trees occur near some of the worst infested plum orchards. The pest may be identical with Dr. Fitch's *L. cerasifex* described in 1856, but this scale has not been again recognized since it was described, so the identity of the two scales could not be definitely established. Mr. L. O. Howard, U. S. Entomologist, writes us, under date of December 17, 1894, that "the most careful studies I have made have failed to lead me to any definite conclusion, beyond the fact that I feel sure the species is not Fitch's *juglandifex*. I simply drop the whole subject for the present, pending the receipt of specimens of the European species from Mr. Douglas." Perhaps this western New York Plum Scale has not yet been christened, who shall say?

or four years, until it has now reached a point where it threatens the destruction of some of the finest orchards in these counties.

We have found but a single reference to a *Lecanium* attacking plum trees in the east prior to 1894. In 1866, a correspondent in Vermont sent a plum branch containing many of the scales to Mr. Walsh, then editor of the "Practical Entomologist" (p. 89 and 100), for identification. Mr. Walsh's notes on the eggs agree so closely with our observations on the Plum Scale this season as to indicate that the Vermont scale was the same insect. Recently, Miss Murtfeldt (Bull. 32, Div. of Ent. of the U. S. Dept. of Agr., p. 41-44) has recorded the appearance in destructive numbers in 1893 of a *Lecanium* on plum and peach in Missouri. This Missouri Plum Scale seems to differ slightly in some of its characteristics and in its life history from our New York Scale, but may not the difference of 5 degrees in latitude between the two localities account for these differences between the insects? Mr. Fletcher recently found a *Lecanium*, probably identical with our New York species, on plum at Queenstown, Canada.* Thus, while we believe that this new plum pest occurs in many orchards outside our state, no definite conclusions can be drawn from the meagre and indefinite evidence thus far reported.

We have also received the insect from Utica and from Prattsburg (Steuben Co.) N. Y., but it has not yet become serious in these localities. The only localities, so far as we know, where the pest is now present in alarming numbers is in several of the large orchards near Geneva, Rochester, and Lockport. Nearly all of the owners of these orchards are thoroughly alive to the necessity of checking this pest at once, and the work of extermination has already begun in some of the orchards.

How long the insect has been present in these localities, is not known. It was seen in considerable numbers in Geneva orchards

*Mr. Cockerell will describe this scale as *L. rugosum* in the coming February number of the "Canadian Entomologist." He says it agrees closely with the New York Scale in microscopic characters, but differs slightly in form. The form of these scales depends so much upon the time when they are collected and killed, whether they are crowded together on the branch or not, and other factors that the mere form of the dead females or their shells does not furnish a sure criterion by which to determine the names of many of the *Lecaniums*.

four or five years ago. We saw it at Lockport in 1893, but as no such scale had before ravaged fruit trees in the east, we did not anticipate any such injury as the pest wrought in this orchard this year.

The destruction wrought by this scale the past summer has been considerable in most of the orchards mentioned above. One fourth of Mr. Hooker's crop from over 2000 trees was so badly damaged that it was not picked at all, while the remainder was more or less dwarfed or presented a smutty appearance. Much of the fruit in these orchards either had to be washed or sent to the market in a "mussy" condition. Many bushels of plums were also "under-size." Thousands of trees made but little growth during the season, and from present indications it would seem as though some of these orchards must succumb in the near future unless this insidious foe is soon checked.

INDICATIONS OF ITS PRESENCE.

One form of the insect itself is so conspicuous, as shown in the figure on the title page, that it may be discovered before it has made its presence felt by any visible effect on any part of the tree. This year, in the worst infested orchards, the trees showed scarcely any visible signs of the presence of the pest until July. During this month the young scales hatched and went onto the leaves and fruit stems where they at once began sucking the sap. So many thousands of these little pumps at work drawing out the sap soon began to tell on the vigor and health of the trees. In consequence, many of the leaves curled considerably, and the trees made but little growth.

But the most noticeable indications of the presence of the pest was caused by the immense quantities of a clear, sweet, sticky liquid known as "honey dew" which the little scales secreted in July and August. A black fungus always accompanies this honey dew, growing in and spreading all through it; and as the sticky fluid was secreted in such quantities as to literally cover the whole tree, the consequence was that badly infested trees presented a disgusting black appearance, as if treated with a thin coat of a sticky smutty substance. This blackened honey dew covered the leaves, doubtless closing up many of their breathing

pores, and gave to the fruit a smutty or "mussy" appearance. The loss of so much sap also dwarfed much of the fruit. Thus a badly infested orchard presents a sorry sight in August, with its stunted growth, curled leaves, and dwarfed fruit, while the whole tree has a disgusting smutty appearance. During the winter these conspicuous blackened trees are unwelcome monuments of the work of the pest during the summer.

Those who have seen the effects of the Pear Psylla on pear trees will at once recognize a plum tree which has suffered from this Plum Scale. Trees attacked by either insect present the same black unhealthy appearance, but the Pear Psylla does not attack the plum, nor does this Plum Scale seem to have yet appeared in destructive numbers on the pear.

ITS FOOD-PLANTS.

This scale is as yet *par excellence* a plum pest ; and we have not seen it on plum trees less than five years old. However, many quince trees near infested plum orchards suffered severely last summer from what appears to be the same insect ; and we have just received an apple branch from Lewiston, N. Y., which bears several similar scales with other indications that the tree has suffered considerably from the insect. It was doubtless the same insect which we saw on a pear branch that projected into an infested plum tree. An elm branch on which were seen many scales doubtless became infested from a plum tree near by. Mr. Hooker reports a similar scale on his honey locust hedge. And Mr. Beach says ("Garden and Forest," July 18, 1894, p. 284) the insect has been found on apple, pear, maple, and *Cissus*. In one orchard, apple and cherry trees in rows alongside infested plum trees have but very few of the scales, while quinces near by are freely attacked. Thus the pest apparently thrives on quince, and may attack apple, pear, cherry, elm, maple, honey locust, and *Cissus*.

We doubt if the pest has any preferences among the cultivated varieties of plums. In one orchard, Smith's Orleans suffered the most, while in another Copper, Bradshaw, and Lombard were the worst infested. The scales are also now present in one orchard

in alarming numbers on Damsons, Reine Claude de Bavay, Quackenbos, and on Prunes. The Japanese varieties have not yet been attacked, so far as we have learned.

THE LIFE HISTORY OF THE INSECT.

Its first appearance and habits in the spring.—As previously stated, the old shells of the female insects are to be found on the trees at any time of the year, but as they no longer play any part in the economy of the insect, they need not be considered in this connection. It is only the small, flat, spindle-shaped, brown scales that need attention early in the spring; these are shown natural size on the branch in figure 1, and also on the portion of board shown in figure 4, where they are scattered among the large spiny skins of a Lady-bird larva. About April 1, or even earlier, these little scales begin to move about on the tree; they are seeking a suitable place to establish themselves. This they usually do on the undersides of the smaller branches. Once established, most of them probably never move from the spot. Each scale inserts its little beak or sucking organ into the bark, and for nearly two months each of these minute pumps is kept constantly at work drawing out the sap.

Remarkable growth of the scales in the spring.—As these little scales have had their appetites whetted by over five months of fasting, their little pumps seem to work with surprising vigor in the spring. The result is that they increase in size remarkably fast. In less than two months last spring, most of the little scales, only 1 mm. (.04 of an inch) in length, grew to the size of the scales shown on the front of this bulletin. Doubtless the scales secrete considerable quantities of honey dew during this period of rapid growth.

Many of these little scales, however, do not grow into these large conspicuous females. But after feeding for a short time, their skin is cast off and it forms a thin, delicate, semi-transparent, whitish, ribbed scale or shell over the pupae; beneath this cast skin the male insect develops. The males are very delicate in structure, and each is provided with two large whitish wings. At

m in figure 2 are shown several of these male scales considerably enlarged; from the lower end of the two upper scales the tips of the wings of the male insect protrude, and in one instance the two long white filaments which project from the end of the insect's abdomen can be distinctly seen extending considerably beyond the wings. At *n* in the figure, a male scale and a female scale are shown natural size, the one on the right being the male. The male scale is thus much smaller, flatter, more elongate, and is of a whitish color. They often occur in considerable numbers among the large brown female scales in May and June. They are rarely seen after June, as they do not adhere strongly and thus soon "weather off." The males doubtless emerge in May, but probably live only long enough to mate with the then mature females. In their early stages, the male scales are scarcely distinguishable from the young females.



FIG. 2—*m*, male scales, enlarged; *n*, male scale and female scale, natural size.

The eggs.—This year, by the 18th of May many of the female scales had become full grown. And by tipping them over at this time, it was found that egg-laying had just begun. The female lays her eggs under her own body. During the process, her outer skin hardens and her body gradually shrivels thus making room underneath for the eggs. Egg-



FIG. 3—*e*, eggs as they roll out from beneath a mother-shell in June; enlarged.

laying continues for a week or ten days, and, what was at the beginning a large fleshy soft-bodied female, becomes, when the task is finished, only a thin hard shell closely adhering to the branch and containing a mass of embryonic life in the form of minute white eggs. If one of these shells be disturbed in June, it will be found packed nearly full of eggs,

which roll out when the shell is tipped as represented in figure 3. In this figure the scale is shown considerably enlarged, but at *n* in figure 2, is another view of the same scale natural size.

This year the egg stage lasted about a month, the eggs becoming pinkish in color about a week before they hatched. Some of the minute active scales emerged as early as June 23, but most of them appeared about July 1. The little creatures remained under the protecting shell for several hours, some of them a day or more, before venturing forth onto the branches. Thus if one of these mother scales is overturned in the latter part of June, it may contain hundreds of the active little creatures and as many more eggs yet unhatched.

The number of eggs laid by a single mother is enormous, reaching into the thousands. We have not counted them under one of these Plum Scales, but others have counted 1054 and 2200 under similar scales of other species of *Lecaniums*.

The young at last venture forth from under the shell, and about July 1 may be seen actively crawling about on all parts of the tree. The old mother shells which they have left contain nothing but a whitish powder made up of minute egg-shells.

Habits of the young scales in summer.—Soon after emerging from the old shell of their mother, the little scales find their way onto the leaves. Here they usually establish themselves close beside the veins on the underside, some take up similar positions on the upperside, while others attach themselves without regard to the veins. In figure 1 is shown the young scales, natural size, thus attached to the leaves. Although there are many more scales on the leaf at the right, they are so nearly the color of the underside of the leaf that they do not show as distinctly as those on the leaf at the left. Practically all of the newly-hatched scales thus established themselves on the leaves, or leaf and fruit petioles, in July. The scales are then so small, scarcely .5 mm. (.02 of an inch) in length, so flat and closely pressed to the leaf, and so near the color of the undersides of the leaves that they can hardly be distinguished without a lens. In some of the worst infested orchards, nearly every leaf bore hundreds of these little scales. With so many millions of little pumps at work on a single tree sucking the sap, is it any wonder that many trees made but little growth and that much of the fruit was dwarfed?

Through the kindness of Mr. C. M. Hooker, who sent us infested leaves from time to time during the summer, we were

able to follow the life-history of the pest closely. The little scales moved about but little, if any, during the summer; and also grew exceedingly slow as compared with the surprisingly rapid growth of their mothers in the spring. In a month the little creatures had gained scarcely .1 mm. (.004 of an inch) in length, and yet they had already caused many of the leaves to curl, the fruit began to show their effects, and the trees presented a smutty disgusting appearance. The amount of honey dew secreted by each individual scale was doubtless very small during the two months (July and August) that they worked on the leaves. But the aggregate from millions of the little scales was sufficient to completely coat the trees, including their leaves and fruit. The pest did more damage this year while in this young stage on the leaves than at any other period of its life.

Fall migration.—August 21, Mr. Hooker wrote us that some of the scales "were on the march." It was found that they were moving to the undersides of the branches where there were still many of the old shells of their mothers from which the little scales had emerged more than two months before. This migration continued until most of the leaves had fallen; probably a majority of the scales had established themselves on the branches by October 1. Most of them sought the undersides of the smaller branches, and in many instances they were to be found in these places in such numbers as to form two or three layers of scales on the bark. Thousands of them, however, crawled into any sheltering crevice on large or small limbs or even on the trunk of the tree. Figure 4 shows how thickly they congregated on the underside of a small piece of board placed under a rope to protect the bark; the large spiny objects on the board are the pupae of a Lady-bird beetle, one of the enemies of this scale described farther on.

In August, the scales became light brown in color, and this deepened into a dark seal brown when the migration began.

Some of the scales did not migrate to the branches this fall. From material sent us by Mr. Hooker, we estimate that about 10 per cent. of them fell to the ground with the leaves. Many of these will doubtless find their way to the trees again in the spring.

Hibernation.—When the scales migrated from the leaves to the

branches, they measured about 1 mm. (.04 of an inch) in length, or were only about twice as large as when they hatched and went onto the leaves in July. These small dark brown scales are at present on the trees in the position to which they migrated in September. They will doubtless pass the winter in this stage, without feeding. Many of these hibernating scales are shown in figure 1; they lie scattered about on the plum branch among a few old mother shells.

It is to these hibernating scales that we referred when we stated on a preceding page that there are at the present moment more than 50,000 of the best plum trees in western New York, each of which is harboring millions upon millions of this Plum Scale. Fortunately, these hibernating scales are tender creatures, and most of them lie exposed on the bark of the trees. Thus this stage is the weakest point in their life history, and fruit growers must take advantage of it this winter. For, as we have shown above, these little creatures grow with astonishing rapidity early in the spring and soon get beyond man's power to check them by any practicable means.

Number of broods.—There is but one brood in a year. The little scales now in hibernation develop into full grown males and females in May. Eggs are soon laid, and this stage lasts nearly a month. About July 1, the young scales emerge and migrate to the leaves where they remain for two or three months, scarcely doubling in size meantime. In September these scales again migrate, going onto the branches where they hibernate.

HOW THE INSECT SPREADS.

As the pest is not very active in any of its stages, it doubtless would spread very slowly if left to itself. At certain seasons, however, especially when the young scales are migrating in July and September, many of them doubtless become attached to the feet of birds that may then visit the trees. The scales could be carried long distances in this way.

The young scales may also attach themselves to larger insects which frequent the trees. Last year, in Maryland, several Lady-bird beetles and ants were seen bearing one or more young

of the San José Scale on their backs; curiously enough, the scales seemed to prefer to ride on the backs of the shining black beetles and ants rather than on the red ones.

Doubtless the wind is an important factor in the spread of this pest. Possibly a strong wind may detach some of the scales and carry them to other trees. The wind also distributes the fallen leaves over a considerable area in the fall; and as many of these leaves contain a few hibernating scales, they would form a fruitful source of contagion. We estimate that about 10 per cent. of the scales are hibernating on these leaves, and many of them will doubtless find their way onto the nearest trees in the spring.

Is there danger of introducing it on nursery stock?—Some newspapers, in commenting on our recent popular discussion of this scale in the *Rural New Yorker* and other papers, have warned their readers to carefully examine all nursery stock sent out by New York nurserymen lest the scale be introduced into their orchards in this manner. This is a very important point, and was made the subject of special investigation and inquiry in our recent trip through the infested region. The result is that, so far as we now know, there is but little danger of introducing the pest into new localities on nursery stock. Nurserymen rarely have the stock more than two years, and it is not usually grown near plum orchards. And furthermore, we have never seen or heard of the scale on any except bearing trees. We have not found it on trees which have been set less than five years in orchards. It is always a wise precaution, however, to examine thoroughly all nursery stock for scales or even borers. You need not expect to find this Plum Scale, but remember that the dreaded San José Scale is abroad in the east and may be introduced on nursery stock. Dig out the borers and dip the trees in a strong kerosene emulsion to kill the scales.

ITS NATURAL ENEMIES.

This Plum Scale doubtless has several insect enemies, but we have met with only two thus far. In May, there were many small, narrow, smooth, elevated, black scales scattered among the nearly full grown females. Some of these small black scales can

beseen on one of the branches in the figure on the title page. A close examination showed that these scales contained parasites; which we did not succeed in breeding. The parasite is probably a minute four-winged hymenopterous fly which lays her eggs in the young scales, perhaps in the fall. The percentage of the scales thus destroyed this year was not great, but this little foe may become a valuable ally in checking this pest in the near future.



FIG. 4.—*Spiny larval skins of Lady-bird Beetles; and many young plum scales in hibernation. Natural size.*

In figure 4 is shown the spiny larval skins, many of them containing pupae, of the twice-stabbed Lady-bird beetle (*Chilocorus bivuln-rus*) which is very common in some infested plum orchards. We have seen hundreds of the spiny skins in groups about the trees, but have not observed the Lady-bird at work on the scales. One of the beetles is just emerging from one of the pupae in the figure. It is a small beetle, about as large as and shaped somewhat like one of the shells of the Plum Scale. But it is of a shining black color and has a bright red spot on each wing cover. This Lady-bird is very com-

mon throughout the country, and is said to be the most effective enemy of scale insects in Florida. Both the beetles and their spiny larvæ feed upon the scales. Protect these little friends.

There are doubtless other Lady-bird beetles that are predaceous on this plum scale, and perhaps other true parasites are at work upon it. But the balance of nature seems to have tipped decidedly in favor of the scale at present in western New York, yet these little foes will materially aid in restoring the equilibrium in the future.

HOW TO COMBAT THE SCALE.

What to use.—This pest obtains its food from the inner tissues of the tree by means of its sucking mouth-parts. Thus none of the poisonous insecticides used to kill biting insects would have any effect on this Plum Scale. It must be hit by some of the insecticides that kill by contact. The one that is the simplest to make and which has been found the most effective here in the east against scale insects is the Kerosene Emulsion.* If the directions are carefully followed there is no trouble in getting a good emulsion. This standard emulsion should always be diluted before it is applied to growing plants. But the number of times it is to be diluted, will depend upon the insect to be killed. The nymphs of the Pear Psylla, for instance, are readily killed by a spray consisting of 1 part of the emulsion to 20 parts of water. For most sucking insects it is diluted with 9 parts of water. But our experiments indicate that this Plum Scale does not readily succumb unless the emulsion as made by the formula is diluted with only about 4 parts of water. That is, to one gallon of the standard emulsion is to be added 4 gallons of water. A greater dilution than this cannot be depended upon to do sure work. There is not the slightest danger of this dilution of the emulsion causing any injury to the tree, even when the leaves are opening in the spring. Do not expect to kill a majority of the scales if you dilute it with 7 or 8 or more parts of water.

When to spray.—Between May and October, there is only one period, of less than a week, in which the insect can be combated effectively and practicably. Our experiments indicate

* To make the emulsion, thoroughly dissolve one-half pound hard or soft soap or whale oil soap in one gallon boiling water. While this solution is still very hot add two gallons of kerosene and quickly begin to agitate the whole mass through a syringe or force-pump, drawing the liquid into the pump and forcing it back into the dish. Continue this for five minutes or until the whole mass assumes a creamy color and consistency which will adhere to the sides of the vessel, and not glide off like oil. It may now be readily diluted with cold rain water, or the whole mass may be allowed to cool when it has a semi-solid form, not unlike loppered milk. This standard emulsion if covered and placed in a cool dark place will keep for a long time. In making a dilution from this cold emulsion, it is necessary to dissolve the amount required in three or four parts of boiling water, after which cold rain water may be added in the required quantities.

that in May the fast maturing females are not susceptible to the emulsion unless it is used so strong as to injure the foliage. The eggs are also safe under their mother's shell during June.

However, the newly-hatched scales which emerge about July 1, can be easily killed with the emulsion diluted even 6 or 8 times. But the application must be made while the scales are moving about on the branches; for if they once get established on the leaves, it will be impracticable to hit a majority of them. By tipping over some of the scales every day or two during the latter part of June, one can tell with a lens when a majority of the scales have emerged. When they have done so, do not wait a moment, but completely drench the trees with the emulsion diluted 6 or 8 times. We visited an orchard in July after the scales had become established on the leaves. Nearly every leaf bore hundreds of the little creatures, but it was evident that man was powerless so far as checking them with a spray was concerned. It would have been necessary to literally drench the undersides of every leaf, an impracticable task with a spray. Nothing but the expensive gas treatment with tents, so commonly used in California, would have been of any practicable use. Thus, the pest cannot be effectively and practicably checked by sprays while it is on the leaves from July 1 until the leaves fall in October. Unless the expensive gas treatment can then be resorted to, fruit growers will be obliged to stand idly by in the summer and see the pest do its most damaging work.

Fortunately, however, the scales grow but little during the summer, and then migrate to the branches where they go into hibernation in a tender stage. Therefore, after the leaves fall in autumn, afflicted fruit growers may begin the work of extermination. The little tender scales are then exposed on the undersides of the branches and in crevices all over the tree. There are then no leaves to bother, and every scale that is hit with the emulsion diluted 4 times, speedily dies. Do not expect to see the scales drop off immediately, or even for several days after spraying. It is difficult to tell a dead scale from a live one. If the branches are brought into a warm room and the scales examined closely with a lens after a few days, life can be detected in the uninjured scales. Dead scales are usually of a distinctly lighter brown color and are somewhat shriveled in appearance; where large

numbers of dead scales occur near each other, this difference in color is easily seen with the naked eye. Doubtless many of the dead scales will "weather" off by spring.

Under our directions, millions of these scales were killed in some of the infested orchards in November. Other orchardists are now carrying on the work of destruction. Nearly all who suffered from the pest last summer realize the necessity of checking the insect before spring opens. The spray will be equally effective if applied at any time between November 1 and April 1, or when the trees are leafless. There is no question about the effectiveness of the emulsion diluted 4 times, but it must be remembered that each scale must be *hit* with it before it will be destroyed.

How to spray.—Thoroughness must ever be the watch-word in applying the emulsion. The scales are very small objects and you must hit them with the emulsion. In making the application about July 1, the only direction needed is to thoroughly soak the trees with the emulsion. In combating the hibernating scales on the leafless trees, however, more care must be taken in directing the spray. Remember that most of the scales are on the undersides of the smaller branches, but there are thousands of them also in the crevices of the bark all over the tree from the base of the trunk to the topmost twig. Thus in order to hit the scales, the spray must be directed from beneath the tree on all sides, and every crevice filled with the liquid. Drench every square inch of the bark. Do not trust the work to some one who does not appreciate the necessity of hitting every scale, or the work will not be half done.

The McGowen and Vermorel nozzles will do the best work. The knapsack pumps are practicable if but a few trees are infested. But in the large orchards in western New York that are now full of the scale, large tanks and strong pumps must be used. The horse power sprayers will not prove nearly so effective in fighting this pest as an ordinary hand pump and barrel or tank apparatus. You have got to stop at a tree, get under it, and stay at least a minute to do a thorough job. Remember where the scales are that you want to hit and do not leave the tree until they are hit. This idea of thoroughness cannot be too strongly impressed on the one who holds the nozzle when this pest is being fought.

Number of applications.—Not one fruit grower in ten will kill half of the scales with the first application of the emulsion. And yet it is only a question of taking the time to do the work thoroughly enough. Fortunately, you have nearly six months in which to do a thorough job. If possible, get in one blow at the pest before winter closes in. Then be ready to strike again whenever the weather is suitable during the winter. And get in another blow early in the spring before April 1. In other words, spray with the emulsion diluted 4 times, at least once in the fall, once during the winter if possible, and once or twice in March; two very thorough sprayings, may suffice in some orchards. To owners of badly infested orchards who failed to get in a blow this fall, we would say, do not let a suitable spell of weather pass this winter or in March without drenching your trees with the emulsion. We are not putting the case too strongly; for if 25 per cent. of the scales, that are now to be found on 50,000 of the best plum trees in our state, are allowed to develop in May, 1895, these trees will be literally overrun with the pest before the year ends.

The cost.—The Kerosene Emulsion is the most easily made and the cheapest of the insecticides used against sucking insects. The Lime, Salt and Sulphur Wash is not so effective, and the Resin Wash is more troublesome to make. Fruit growers who sprayed this fall, bought kerosene for $4\frac{1}{2}$ cents, per gallon, and soap for from $3\frac{1}{2}$ to 8 cents. per pound; the soap is a small item in any case.

One man made 125 gallons of the diluted emulsion (diluted four times) for \$1.12, with soap at 8 cents per pound. With this 125 gallons, 80 trees were sprayed in 40 minutes. Another man sprayed 8000 trees with the emulsion diluted only twice at a total cost for labor and material of less than \$70. The work in the latter case was done with horse power sprayers, but not nearly so many scales were killed as in the former case where more than four times as much liquid was applied to each tree.

The labor necessary to do thorough work will cost about as much as the materials used. So that, on an average we believe that one thorough application can be made to a tree 10 or 15 years old for a total cost of not over 3 cents. This may seem a large expenditure to a fruit grower with several thousand badly infested plum trees. But let him recall how much time and

money have been put into those trees to bring them to their present condition, and also then realize that unless this pest is soon checked it means the ruin of his orchard in the near future. Every tree could be drenched with the emulsion a dozen times for less than one-eighth of the money that is realized from one good crop from the tree. No time should be lost in trying to devise some way of checking this pest with little expense. The insect is now present in full force and drastic measures are necessary. Every day's delay in trying to save a penny, means dollars of loss next year if the pest gets the start of you in the spring.

Briefly summarized, the way to combat this pest is to spray the infested trees several times, at least twice, this winter or before April 1 with kerosene emulsion diluted with four parts of water. Always bear in mind that each little scale must be hit with the liquid. Do not let the pest get started in force in April. If it does, you cannot fight it effectively until about July 1. Then the young are hatching and while they are wandering about on the branches for a few days, they can be successfully destroyed by the emulsion diluted even six or eight times. If these young scales get established on the leaves in July, they will be beyond your control with a spray until November. You will be helpless against their ravages during the summer months. But the moment the leaves fall, begin the work of destruction on the tender hibernating scales then exposed on the bark. Thoroughness must be the watchword, if this new and most serious enemy is to be checked.

MARK VERNON SLINGERLAND.

30.679
V7
2821

UNIV. OF MICH
JAN 18 1909

Bulletin 84.

January, 1895.

Cornell University Agricultural Experiment Station,

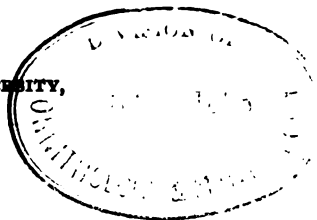
HORTICULTURAL DIVISION.

THE
Recent Apple Failures
OF WESTERN NEW YORK.



By L. H. BAILEY.

PUBLISHED BY THE UNIVERSITY,
ITHACA, N. Y.
1894.



ORGANIZATION.

BOARD OF CONTROL:

THE TRUSTEES OF THE UNIVERSITY.

STATION COUNCIL.

President, JACOB GOULD SCHURMAN.

Hon. A. D. WHITE,	-	-	-	-	Trustee of the University.
Professor I. P. ROBERTS,	-	-	-	-	President State Agricultural Society.
Professor I. P. ROBERTS,	-	-	-	-	Agriculture.
Professor G. C. CALDWELL,	-	-	-	-	Chemistry.
Professor JAMES LAW,	-	-	-	-	Veterinary Science.
Professor A. N. PRENTISS,	-	-	-	-	Botany.
Professor J. H. COMSTOCK,	-	-	-	-	Entomology.
Professor L. H. BAILEY,	-	-	-	-	Horticulture.
Professor H. H. WING,	-	-	-	-	Dairy Husbandry.
Professor G. F. ATKINSON,	-	-	-	-	Cryptogamic Botany.

OFFICERS OF THE STATION.

I. P. ROBERTS,	-	-	-	-	-	Director.
E. L. WILLIAMS,	-	-	-	-	-	Treasurer.
H. W. SMITH,	-	-	-	-	-	Clerk.

ASSISTANTS.

M. V. SLINGERLAND,	-	-	-	-	-	Entomology.
GEO. C. WATSON,	-	-	-	-	-	Agriculture.
G. W. CAVANAUGH,	-	-	-	-	-	Chemistry.
E. G. LODEMAN,	-	-	-	-	-	Horticulture.
MICHAEL BARKER,	-	-	-	-	-	Horticulture.

Office of the Director, 20 Morrill Hall.

Those desiring this Bulletin sent to friends will please send us the names of the parties.

BULLETINS OF 1895.

84. The Recent Apple Failures in western New York.

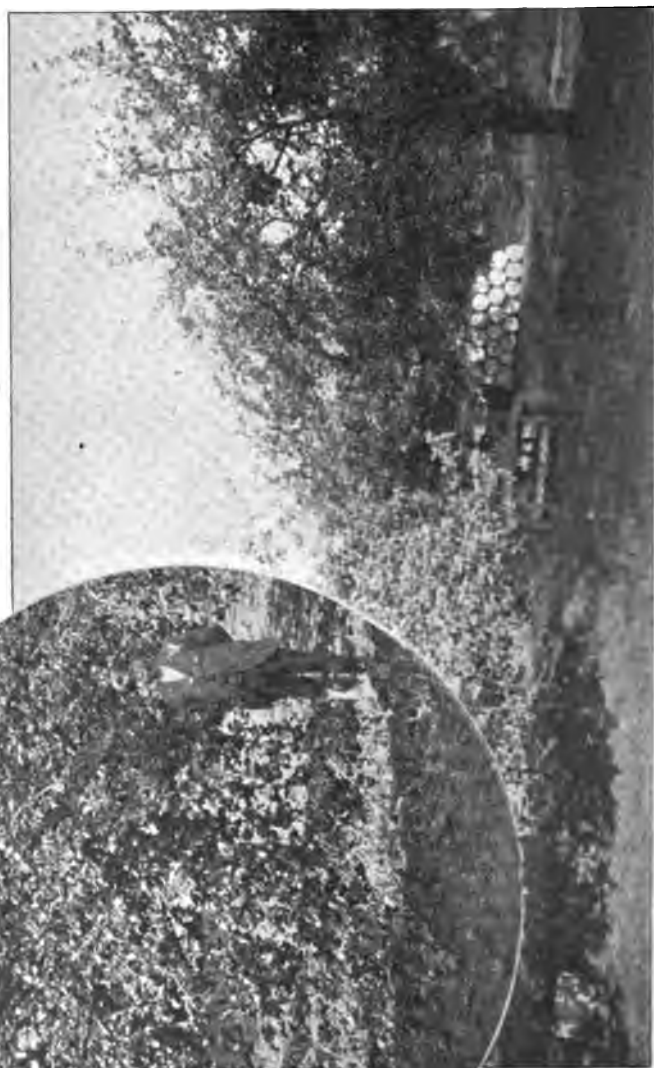
CORNELL UNIVERSITY, ITHACA, N. Y., }
January 15, 1895. }

THE HONORABLE COMMISSIONER OF AGRICULTURE, ALBANY.

Sir: The most important fruit interest of western New York is apple-growing, and it is also the one which has been subject to the most disastrous failures during the past decade. I have attempted to discover the causes of these failures, and the larger part of last summer was spent in a careful examination of apple orchards in various parts of the Fifth Judicial Department; and experiments in the fertilizing of orchards were inaugurated. It was the original intention to present a full account of these surveys, describing specific cases both of failure and success in apple-growing; but the account would be so voluminous that I forbear, and I now submit the summary conclusions of the investigation. The statement is proposed for publication under Section 87, Chapter 675, of the Laws of 1894. A detailed sketch of spraying experiments of the year will appear in Bulletin 85. A synoptical guide for the operator will be found in the new Spray Calendar.

L. H. BAILEY.

Overloaded with Krings. W. T. Mann (See page 22.)



1. A renovated orchard. Sorting-table in the foreground. Albert Wood. (See page 26.)

THE RECENT APPLE FAILURES OF WESTERN NEW YORK.

The causes of the failures of our apple orchards are various, and it is likely that many of them are not understood or even known. I am satisfied that the first and fundamental cause is neglect. For twenty years and more, our apple growers have sown neglect; they are now reaping the harvest.

More than half the apple orchards of western New York have been turned out to grass from the time they were set; and even the grass has too often been sold at the city market. Land will not grow good meadows and good orchards at the same time. The grass takes the cream of the land. Apple trees which have been fed on skim milk for a quarter of a century must be expected to be lean.

If grass has not been profitable, the orchard lands may have been sown to grain, and the farmer usually complains if the grain is not a good crop. The trees are not thought of as requiring ground space and food. Orchardists generally consider, too, that the crop, in an apple orchard, is the fruit; but the crop is really the orchard itself, for the soil must nourish the trees day by day, just as it nourishes a crop of corn or hay. The orchard is a continuous crop upon the land, whether it bears or not. The most delicate morsels of the soil are taken by the wheat and oats; and these plants appropriate the water from the rains and there is no tillage to conserve soil-moisture. The apple trees feed upon the husks, and are then obliged to share their portion with borers, tent-caterpillars, fungi, and twenty other tramps.

Of late years, attention has been given almost wholly to these tramps, by the use of the sprays. This is essential; but it is evident that this is not the primary or fundamental treatment for an apple orchard. Food and moisture are the first considerations. People say that spraying is not always sure to bring a crop. Certainly not! One cannot feed a horse by using a curry-comb. It is a wonder that, in the average orchard, the spray is ever suffi-

ent to secure a crop ; but the fact that it often is, is proof of the wonderful constitutional vigor of an apple tree and the pertinacity with which it holds on under discouragement.

Some persons who have cultivated, fed and pruned their orchards for the past few years, and have sprayed in the bargain, have yet failed to secure good crops. This is not surprising. One should not expect to correct the evils of years of neglect by a spurt of repentance ; and the evil is the worse, too, for having been wrought when the orchard was young, for "as the twig is bent, the tree's inclined." Orchards which have been many years in sod and neglect, are occasionally thrown into such exuberant growth by tillage and fertilizing that they do not bear. Such a change would, no doubt, be a surprise to most western New York orchards, and it would be no wonder if the trees should jump out of their boots. In such case, the orchadist should aim at a moderate growth by stopping cultivation early in the season (say the middle or last of July) and by the sparing use of nitrogenous fertilizers. Yet this treatment—liberal tillage, fertilizing, pruning and spraying—is the best which can be recommended for old and unprofitable plantations, and if it will not revive the old trees the only remaining treatment is to plant a new orchard.

So long as trees blossom profusely, they should bear. Perhaps the bloom oftenest fails because of the attacks of the apple-scab fungus, an opinion which was first expressed, so far as I know, in our Bulletin 19, which was devoted to the fruit failures of 1890 in western New York. When this is the case, Bordeaux mixture is a specific. Frequently, the trouble is the codlin-moth worm or other insects, and for these Paris green is a specific. But the flowers probably often fail to set fruit because the tree is not sufficiently nourished to sustain them. Unfortunately there is no complete specific for this difficulty, for the orchard may be in such condition, from long neglect, that the land cannot be properly tilled and the trees cannot be adequately fed. One of the best methods of feeding the tree is to keep it well pruned, for the food which is diffused in numbers of worthless limbs is then concentrated in a small number. And it is only the well pruned trees which are capable of successful treatment with the sprays.

* * *

Good tillage should be the first intention of the apple grower. But this can be satisfactorily given only in orchards which have been properly planted. The roots should be deep enough to allow of easy plowing, not only because the tillage may thereby be improved, but also because the roots are then in moister earth and they suffer less from dry weather. Planters frequently make the mistake of setting their trees too shallow. It is probably better to have them stand rather deeper in the orchard than they did in the nursery; but whatever depth the person may design to plant them, he should make allowance for the settling of the soil. Land which has been for some years in pasture, meadow, or grain, is elevated or loosened by plowing, and it frequently requires an entire season of good tillage to compact it to its normal level. But the trees are set in the subsoil, and therefore do not settle; and the owner may find at the end of a year or two that his trees seem to stand too high out of the ground. When setting trees on newly turned land, the planter should allow one or two inches for the settling of the soil, and thereby increase the depth of the planting.

Now, if the soil is deep and well drained, and the trees are properly planted, rather deep spring plowing is recommended for the first few years. The exact depth to which the furrow may be run will depend much upon the soil, but it should rarely exceed seven or eight inches. It is probably best to plow apple orchards early in the spring, but not in the fall unless it may be found, by experiment, that plowing under the leaves in the fall lessens the attacks of apple scab. Fall plowing leaves the surface in bad shape for the winter, and it serves no purpose. Yet it should be said that apple orchards are less likely to suffer from fall plowing than many other kinds of fruits, for the trees are hardy, and not likely to be forced into fall growth and are not induced to start so early in spring as to be caught by frosts. But there is no occasion for plowing apple orchards in the fall, as a rule, so far as we know.

Till the soil frequently and lightly during the late spring and early summer. The general methods of cultivating orchards, and the reasons for them, are discussed in Bulletin 72, to which the reader is referred; but the leading points may be reviewed here.

Let us first consider the relation of tillage to moisture. The land obtains its water from rains. This water is held in the interstices of the soil, and it gradually passes off into the air by evaporation. In finely compacted soils, the water which is in the lower levels is gradually raised to the surface by capillary attraction. A mulch of straw placed upon the surface, prevents this soil-moisture from coming into immediate contact with the atmosphere and it therefore keeps the soil moist. Two to four inches of loose fine earth acts in essentially the same manner,—it mulches the soil beneath by breaking up capillary attraction, and preventing the soil-moisture from reaching the atmosphere. This loose top soil may itself be as dry as ashes, but it still conserves the moisture beneath. Every farmer knows that a "baked" soil soon becomes dry; and he also knows that the soil underneath a well tilled surface is always moist. It is evident that, if one wishes to conserve the greatest amount of moisture, he must begin his tillage early and he must continue it uninterruptedly throughout the season. Above all things, he will cultivate soon after a rain, to prevent a crust from forming. The past season was one of almost unprecedented drought in New York. Most farmers suffered severely, and as a result the winter meetings are full of discussions of methods of irrigating lands. But the best irrigation in this state, for orchards, is frequent shallow cultivation—repeated every week or ten days so long as one wishes to keep his trees growing. The long dry seasons of California are made fruitful by constant tillage. By its use, orchards are now growing profitably without irrigation in certain western lands where the annual rainfall is said to be less than ten inches. With our thirty to fifty inches of rainfall, there is little need for irrigating orchard lands, if we take care of the water which we have. In the burning heats of last summer, when everyone was asking for water, I visited a raspberry grower, upon sandy soil, who was afraid it would rain and spoil his berries! His patch was crisp and fresh and loaded with fruit. "But you must have rain to ripen your crop," I said. "No," he replied, "drought never affects me. I water my land with the cultivator."

But tillage means more than conservation of moisture. It promotes nitrification, and enables the plant to unlock more of the

mineral elements than it otherwise could do. Every good soil is a mine of plant-food, and the first thought of the farmer should be to utilize it. The buying of fertilizers should be a second thought. As a rule, an orchard should never be seeded down; or if sod appears to be necessary, pasture it close. Do not make a meadow of the orchard nor attempt to raise grain in it, even from the beginning. Hoed crops may be grown during the first few years, if one cultivates well and allows sufficient space about the trees,—and tree roots extend much farther than farmers are aware,—but the temptation is to continue the practice too long and to expect too much from the crop. If the trees are to be of secondary importance, do not plant them! It will be cheaper to leave them in the nursery.

Persons often tell me that they know of productive orchards standing in sod. So do I; but this only proves that the land is unusually good. The great majority of orchards contradict this experience, and reason is against it. For myself, I should consider that I could not afford to run the risk of placing orchards permanently in sod. There are cases in which thrifty young orchards can be thrown into bearing by seeding them down, but this is only a temporary expedient, and if the land is again brought under cultivation when the desired result is obtained, no harm will come. If the old orchard is giving satisfactory returns in sod, it would be folly to plow it up; but if it is unprofitable, something must be done. Next to tillage, pasturing closely with sheep or hogs is the best thing which can be done; and if the stock is fed grain, so much the better.

Thus far, I have spoken of apple orchards which have been under good treatment from the first. How shall we manage the old orchards, which have been neglected for years? Such orchards, of course, are in sod. The roots are so high that the land cannot be plowed. In this case, the best that can be done is to break up the turf in spring when it is soft, using a sharp-toothed or disc harrow. When the sod is once well cut up, sow on fertilizers, and continue to work it shallow. But the tree tops are often so low that a team cannot be used. An orchard in which horses cannot be driven is worth little, and it is doubtful how much labor can be spent upon it with profit. Trees which have been

cultivated from the first have their tops formed by gradual and timely prunings, the owner scarcely knows how ; but the untilled trees often develop into brush-heaps, which no amount of good intentions can correct. But, if possible, these old orchards must be trimmed up to admit of cultivation. Swine can sometimes be utilized as plows in such orchards. With a crowbar make holes three four or inches deep all through the orchard and drop a handful of corn or buckwheat in each hole. Let the hogs root for it !

As to fertilizers for the apple orchards, little can be said within the limits of this paper. In orchards which have been well tilled from the first, there will seldom be any need to add much, if any, commercial nitrogen. If the trees apparently need it, a sufficient supply may usually be had from the use of crimson clover (see Bulletin 72). Potash is considered to be the dominant factor in fruit production ; this and phosphoric acid should be added each year. In using concentrated fertilizers, the grower should bear in mind that his object is to feed the plant, not to fertilize the soil. That is, it is better to add each year about as much as the plant may be supposed to need, rather than to occasionally apply a surplus with the idea that it will be of use in future years. It is true that the best effect of fertilizers may appear in the second or even in the third year after application, but this does not affect the proposition. It is also true that potash and phosphoric acid do not escape from the soil, as nitrogen does ; but any superfluous amount is likely to become more or less mechanically locked up in clods of earth, and it may be shifted by the movements of soil water. And there are some plants, at least, which take up more phosphoric acid than they need, when this material is applied in redundant amounts. At all events, if I had more commercial fertilizer than the trees would evidently need, I should rather have it in the barn than in the ground.

* * *

But the immediate cause of most of our apple failures of the last few years, is undoubtedly the apple scab fungus. In the first place, it should be said, however, that only a small part of the flowers, when the bloom is full, should be expected to set fruit. Apple flowers are borne in clusters of six to twelve, but the apples are usually borne singly. These superfluous flowers undoubtedly

furnish pollen for the ones that set. The picture shows the normal blasting of the flowers. This cluster had seven flowers, and six of them are now withered and dead, whilst the seventh has passed into an ambitious apple.

Many of the one-sided apples owe their deformity to imperfect pollination. Such a one is shown in the cut. The apple has five carpels or cells, each cell containing, normally, twin seeds. Now each of these



2. Normal failure of apple flowers. Only one has set fruit.

twins is fertilized by pollen which falls upon that one of the five stigmas which is attached to that carpel; and if no pollen falls upon this particular stigma, the seeds will not develop and the apple grows slowly upon that side.

This apple scab is no new pest. It has no doubt been seriously present ever since apples were grown in the country, causing many failures of crops which were laid to the weather or the moon. But within the last decade, it



3. Lop-sided apple, due to imperfect pollination.

seems to have been unusually destructive in the orchards of western New York. It is now enforcing attention to the condition of our long neglected orchards, and it will undoubtedly be the means of greatly improving the apple industry of the country. It is most familiar in the scab-like patches upon the fruit. The small scabs upon mature apples are probably due to infections rather late in the season. If the fungus attacks the fruit when it begins to grow, the apple may become one-sided, and later on

it may crack ; or the apple dies and falls. The earlier the apple is attacked, the greater is the injury, and, as a rule, the very earliest attacks in bad seasons, are fatal. Various stages of injury upon the fruit are shown in the colored plate. Fig. 4 shows a Northern Spy taken July 5th, last year. This apple is now deformed by the attacks of the scab, and if it had remained upon the tree it would probably have become a gnarly, crooked specimen entirely unfit for use. It is probable, however, that the fungus patches upon the stem would have soon cut off the food supply, causing the apple to fall. Fig. 6 is a Greening picked September 20th. The deep fissures have resulted from the checking of the



4. *Apple injured by Bordeaux mixture.*

growth of the fruit by the fungus. At the lower side of the apple are shown two small scabs which are dead and harmless. The tissues of the apple have grown beneath them, and have broken them apart.

During the past summer, this scab upon the fruit has been confounded by some persons with an injury wrought by the Bor-

deaux mixture itself. This injury is a russeted surface of the apple upon the sprayed side, much like that shown in the accompanying illustration. It appears to come mostly from the use of Bordeaux mixture which has an insufficient supply of lime to satisfy the reactions which occur, in a wet season, after the mixture is applied to the tree. In seasons like the last, the use of the ferrocyanide of potassium test for the preparation of Bordeaux mixture is probably unsafe. This injury is not often serious, and the fruit more or less outgrows it; but I have seen a number of cases during the past season in which I was satisfied that the mixture had been the cause of the dropping of the fruit. Pears seem to suffer most, and in some instances,

the crop was nearly ruined by the spray. The climatic conditions which made this injury possible may not recur in many years, but last year's experience in western New York has taught the importance of using freely of lime in the preparation of Bordeaux mixture. There was more or less of this russet injury upon many orchards sprayed with the Bordeaux mixture made by the regular formula, and it was even often present upon unsprayed trees. It is evident that the weather was sometimes directly responsible for it, but the injury was never serious, so far as we could determine, except upon those trees which were treated with the mixture made with the ferrocyanide test. A similar effect of the Bordeaux or the arsenic was common upon the foliage of sprayed trees, the injury appearing in the form of circular dead, brown spots, but even in the worst cases which I saw the leaves were much less injured than they evidently would have been by the fungus. A fuller discussion of this matter will occur in Bulletin 85. For an account of a similar injury upon the quince, see Bulletin 80.

The most serious injury wrought by the fungus in western New York in recent years is upon the foliage. Its first visible attack, upon the under side of a leaf in this case, is shown in Fig. 7 in the colored plate. It is simply a light olive-green discoloration, appearing in small patches. Fig. 5 is a leaf badly attacked in many places, chiefly along the veins, where the disease causes dark, sooty elevations; and patches of it are often seen on the leaf-stalk. The lumpy character of these patches is perhaps a trifle exaggerated in the printing of the plate, but otherwise the picture accurately represents a leaf badly attacked by the fungus. These attacks cut off the food supply of the parts of the leaf beyond, and the leaf becomes dry and curled, its edges die and are torn by the wind, giving the tree the blighted appearance which is familiar to all New York apple growers. A spray of this ragged, blighted foliage is shown in the illustration on the next page. This condition of the foliage is often serious even when the apples themselves are very slightly attacked, and it is sometimes so bad that most of the foliage falls in early summer. It has been at its worst early in the season during the past few years, no doubt because the weather has been favorable to its spread when the foliage is young. It is evident that trees with such foliage as this

can neither mature a crop of apples nor lay up much store of energy for the following year. Those not familiar with the conditions in western New York, can have little idea of the wide-

spread prevalence and great virulence of this leaf-blight. Coupled with poorly fed and thirsty trees, it has wrought sad havoc in a land which has long been famous for its abundance of apples.

The colored plate also shows an individual colony of the apple scab fungus upon a leaf, much magnified, as it appears late in



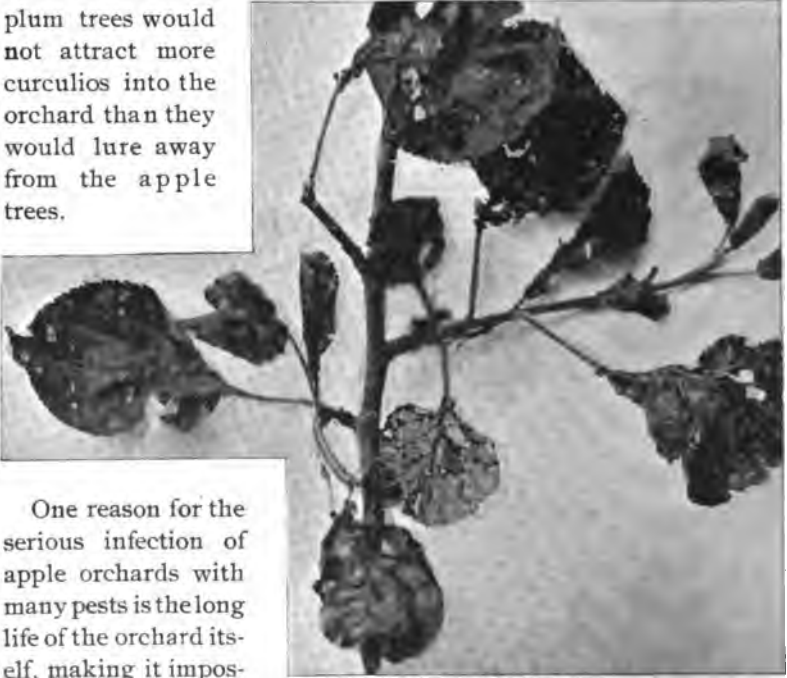
5. *Blighted foliage of Fall Pippin, taken June 29.*

the season. Figs. 1, 2, and 3 represent cross-sections of a leaf. In Fig. 1 the leaf is healthy. Observe the regularity of the three upper layers of cells. In Fig. 2, the brown fungus may be seen

growing on the upper surface, and at this date it has destroyed the upper or epidermal cells, although it is probable that the mycelium of the fungus first spreads just under the cuticle, on top of the layer of epidermal cells. Fig. 3 shows the fungus when it is better established, and it will be seen that all the cells of the leaf are disarranged, the chlorophyll or green grains being fewer in number, and the leaf has increased in thickness. This Fig. 3 is a cross-section through one of the blister-like elevations which are shown on the leaf in Fig. 5. It will be seen that the fungus does not enter the deeper tissues of the leaf, although it disorganizes them by its parasitic effects. In Fig. 3, a spore can be seen at A, and two are shown broken off their stems or hyphæ, at B. In Fig. 2, the spores can be seen in process of formation at the ends of the threads, and at C one of the threads is cut off. The fungus itself is supposed to pass the winter on young shoots, fallen leaves, and upon the fruit. The spores form at a low temperature, and the early cold wet weather of recent years has afforded excellent conditions for the spread of the fungus. The apple scab is one of the so-called "imperfect fungi,"—a name given to those fungi of which the perfect form is unknown. The reader will recall that some fungi, like the quince rust (see Bulletin 80), have two very unlike forms which sometimes live upon different plants. There is every reason to expect that the apple scab passes part of its existence in another form; and it is possible that the discovery of this other form may give us a new means of combatting the disease.

Various insects cause the occasional failure of the apple crop over considerable areas. One of the worst of these in western New York is the bud-moth (see Bulletin 50). Another one, which was serious in Wayne and Monroe counties last year, is the cigar-shaped case-bearer (*Coleophora Fletcherella*), an account of which may be expected later on from the Entomological Division. The work of this insect upon the foliage is shown on the next page. The plum curculio has also been a serious pest upon apples in some places, puncturing the apples and causing them to grow gnarly. Its marks may be seen upon two of the young apples shown on the cover. The apple-worm, the larva of the codlin-moth, is too familiar to need description, and is now pretty

generally held in check by Paris green. The same remedy will also apply to the bud-moth and case-bearer. For the curculio, there is no good remedy upon the apple. It is doubtful if its numbers are greatly lessened by arsenical sprays. Some persons have recommended the planting of plum trees in the apple orchard for the purpose of attracting the curculios, and from these trees the insects can be jarred onto sheets. It is a question, however, if the plum trees would not attract more curculios into the orchard than they would lure away from the apple trees.



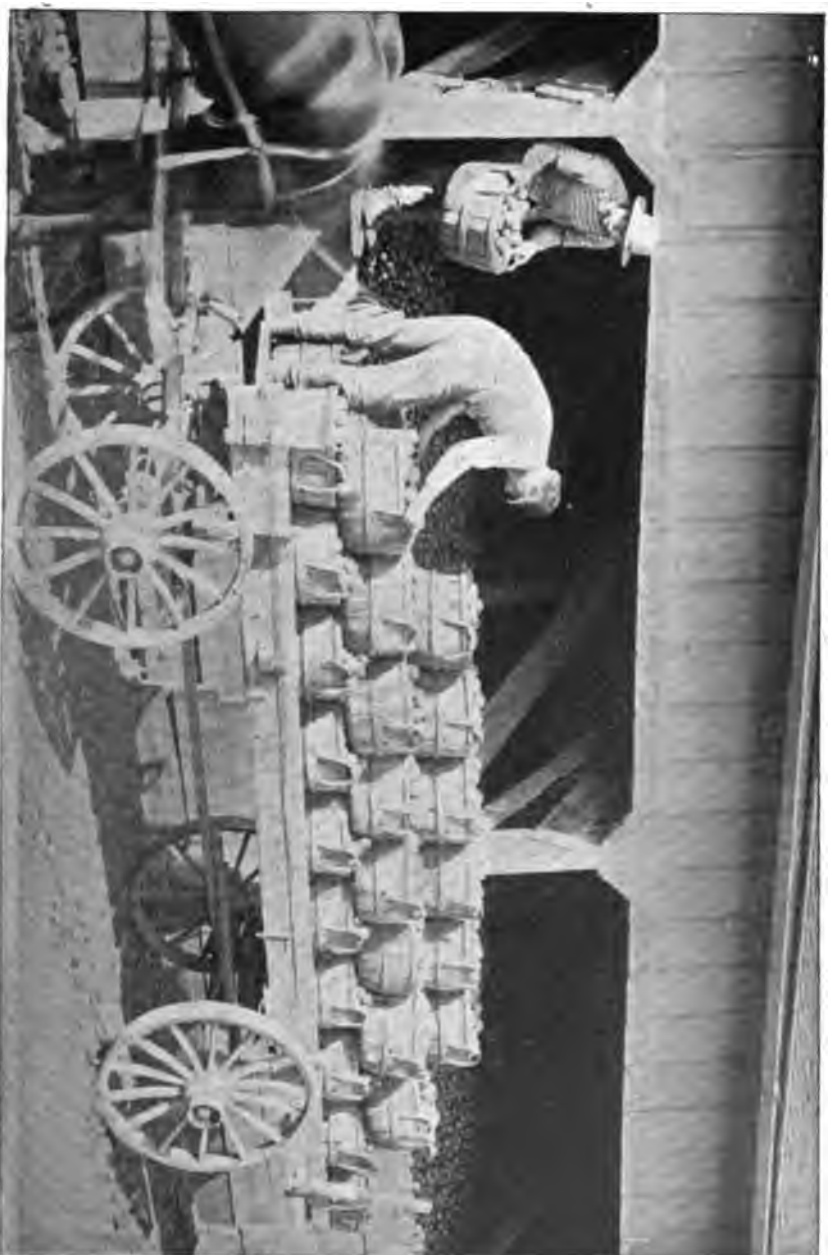
One reason for the serious infection of apple orchards with many pests is the long life of the orchard itself, making it impossible to rotate the crop. It is well

6. *Work of the cigar-shaped case-bearer. June 14.*

known that a frequent and proper rotation of crops is one of the most efficient means of keeping insects and fungi in check. This is true even of small-fruit plantations. Our best blackberry and raspberry growers, in regions where there is likely to be trouble with anthracnose and root-galls, fruit their plantations only two or three years, and by the time the enemies become threatening the patch is destroyed. But with apple orchards this is impos-



THE APPLE SCAB FUNGUS.



7. Apples that pay. T. G. Yeomans & Sons. See page 21.

sible. The large, thick-topped trees become unmolested breeding-places for disease decade after decade. So orchards, of all other crops, should receive the most painstaking treatment for insects and fungi.

* * *

The best proof that the apple scab fungus is the immediate cause of the greater part of the apple failures of western New York is afforded by the fact that thorough spraying with Bordeaux mixture is usually followed by a great increase in the productive-ness of the orchard ; and it may be said that the indifferent results which occasionally follow the spray are equal proofs that there may be other causes than the fungus, for the failures. Much of the failure with the Bordeaux mixture, however, is due to careless or hasty application. If the Bordeaux mixture is properly made—using an excess of lime—no injury may be expected to follow its use, and it should be applied with great thoroughness. The operator should endeavor to completely cover all the leaves and shoots. A mere sprinkling such as most persons give, is of little good. One thorough application which drenches the tree, is better than several of this ordinary kind. Then people are always waiting for fair weather. Now, it is in the rainy weather that the fungi spread most seriously, and it is then that the spray is most needed. With plenty of lime, the mixture adheres well. Spray between the showers, even when the trees are wet, if you can do no better. To delay is to fail. It is better to spray in the rain than not to spray at all.

There is abundant proof that two to four applications of Bordeaux mixture are capable of keeping the fungus almost completely in check. It is not known what value there is in an application before the buds open, but it can do no harm, and it is probable that it is very serviceable in most seasons. At the latest, spraying should begin as soon as the blossoms fall. Make the Bordeaux mixture with 6 lbs. of copper sulphate, 4 lbs. (or more if the lime is air-slacked) of lime, and about 40 gallons of water. It is always advisable to add Paris green for various insects,—1 lb. to every 250 gallons of the mixture. Then take up your position near the tree, with a strong pump, and apply the mixture until the tree is soured.

Does the Bordeaux mixture kill the scab fungus, or simply keep it off? To test this matter, marked leaves and fruits were immersed, upon the tree, in Bordeaux mixture on June 20, July 4, and July 26. All the leaves and fruits were badly attacked with the fungus at the time of the first application. Without going into details, it may be said that none of the treated leaves recovered from the attacks of the fungus, but most of them were in better condition when growth had ceased, in August, than similar check leaves upon the same shoots. Those which were so badly diseased when the experiment began that the edges had begun to roll or curl, fell off in July, whether treated or not. The only very marked benefit coming from the treatments of Bordeaux upon leaves, was seen in the case of two similar large leaves of Siberian Crab, standing side by side. When the experiment was begun, these leaves were just beginning to show the debility due to the infection of scab, but no definite scab patches had developed. One leaf was treated, and the other not. When the second application was made, two weeks later, no difference could be detected between the two leaves, and the disease had progressed little. But from this time on, the treated leaf suffered little extension of the disease, but the other developed scab-patches, and prominent blisters raised upon the upper surface, the leaf finally appearing much like Fig. 5 in the colored plate. Upon the young fruits there was a more distinct benefit from the treatment. In every case, the Bordeaux confined the spots to very nearly their original dimensions, and in one or two cases the scab was wholly killed. On one fruit of Siberian Crab, there were several scab-patches an eighth of an inch across when the treatment began. These spots had not enlarged two weeks later, and a month after the first treatment—the apple having been dipped twice in Bordeaux—the patches appeared to be dead, but a new growth of the fungus had started beyond the rims of the original spots. In another case, five scabby apples upon one twig were treated the three times, and on two of the fruits the scab was certainly wholly killed, notwithstanding that the injury at the time of the first treatment was quite as serious as that upon Fig. 4 in the colored plate. The patches of scab broke away, the apple resumed its growth underneath, and in their places there appeared a scabby russet surface

like that made by the injury of the Bordeaux mixture (as described on p. 12). In one case, in which the spots of scab had nearly encircled the little fruit, the apple grew most rapidly upon either end, leaving a russet valley or zone extending nearly around the fruit. But if anything was gained by the killing of the scab, it was generally lost by the injury of the Bordeaux mixture itself, for half of the treated apples finally dropped. It will be recalled that these apples were immersed, the mixture being held in a cup, and the fruits were allowed to lie in it a half minute at each of the three applications. Some of the apples did not appear to be injured by this treatment, but many of them evidently were. I have made careful examinations of the young apples in sprayed orchards, and I am satisfied that the small and recent patches of scab are sometimes killed outright, but the chief value of the Bordeaux mixture certainly lies in preventing an attack or checking the spread of the fungus.

* * *

Apples can still be profitably grown in western New York. This is proved by the experience of a number of orchardists. I have visited over twenty orchards in the western part of the state this year in which there were large crops of excellent quality, but all of these had been sprayed with Paris green or Bordeaux mixture, or both, all of them were pruned and the land was in "good heart." Most of them were cultivated. The general run of orchards were almost barren this year, and the smallness of the crop was usually in proportion to the degree of neglect in which the orchards were growing. I have asked a number of the successful growers, whose orchards I have inspected, to prepare me a statement of their methods, and their accounts are here given. Several correspondents also report good crops of apples this year, and all of them attribute their success to careful treatment either of tillage, fertilizing or spraying. Amongst these are E. W. Catchpole, North Rose, Wayne Co.; Lyell Hill, Morton, Orleans Co.; J. Van Vorheis, Fisher's, Monroe Co.; J. B. Collamer, North Parma, Monroe Co.

T. G. Yeomans & Sons, Walworth, Wayne Co. (see cut on page 17).

We give the following statement of our experiments in spraying our apple orchards the past season.

This being the first season in which we have sprayed our apples with Bordeaux mixture, we feel reluctant to say too much in its favor till we have had more experience, except to say we are so well satisfied with the results that we shall repeat the same next year more extensively. We have about one hundred and thirty acres of apple orchards, which have been planted from thirty to forty-eight years, and which are nearly all Baldwins. Our spraying tanks hold about three hundred gallons and they are made like a threshing tank. The men who spray, stand on a platform on the rear end of the tank, about nine feet from the ground. This platform is made to project about one foot beyond the outside of the tank on each side, thus enabling the men to stand outside of the tank proper, and allowing them more room in which to work. A strong rail on the four sides of the platform prevents the men who spray from falling off the platform, and allows them to spray more securely and with less fear of being thrown off by the moving of the team. Each man has about twenty-two feet of hose, the upper part of which is tied to a light pole twelve feet long to elevate the nozzle. The driver pumps, and the two men on the platform direct the spray, the three men alternating work. A small boy on the tank agitates the water with a hoe through the open trap in the top of tank, when the team is standing still, closing the trap when the team is in motion, to prevent slopping. We shall endeavor, however, to devise some automatic agitator, for the purpose of saving expense; and we shall expect, of course, to modify our outfit from year to year, as experience and the progress of invention seem to warrant. We used a Gould's double spray pump, No. 905, and a Nixon nozzle, No. 3 cylinder with a No. 2 bottom, for all large apple trees, which gives the nearest approach to a perfect mist which we have been able to throw into the tops of our apple trees. We use thirty-two pounds of sulphate of copper to a tank, using the yellow prussiate of potash test for the quantity of lime, and always using two pounds of London purple per tank. The sulphate of copper we dissolve in suspension, in quantity, so that each gallon contains two pounds of the copper. We would advise that experiments be made to ascertain if enough more lime should not be added, after the potash test, to neutralize the acid in the London purple, the same as is done when it is used without the Bordeaux.

Plot A.—Sprayed twice before and twice after blossoming, viz.: April 26th and May 3d, (blossomed May 6th to 8th); May

22d, and June 4. This plot had a full crop of nice apples, several large limbs breaking from the weight of the apples. All Baldwins.

Plot B.—Sprayed twice before and once after blossoming: April 27th, May 5th, and 30th. One outside row not sprayed and had but few apples; the balance had a full crop of choice apples. All Baldwins.

Plot C.—Sprayed once before and twice after blossoming, viz.: April 30th, May 22d, and (because of rain) May 30th to June 4th. This plot had about a half crop of very nice apples,—Baldwins and Greenings. An outside row of this plot, which was not sprayed, did not have a peck of fruit per tree.

Plot D.—Sprayed once before and once after blossoming, viz.: April 27th and May 30th. Result, half to two-thirds of a crop of Baldwins.

Plot E.—Thirty-five acres of Baldwins, blossomed as full as the others, but was not sprayed with Bordeaux. Result, a very light crop and foliage very badly injured by scab.

We are not prepared to advance the opinion that a crop can always be secured by spraying, nor that a crop cannot be grown without, for there are too many exceptions to attempt to establish any such rule. We are inclined to the opinion that we have not fully realized the importance of *early* spraying, and are convinced that very few persons spray *thoroughly*.

Whenever we have a period of long continued wet weather about the time the apples are setting, we have noticed that there is a very general complaint that "apples are not setting well," "apples are falling off badly," "my apples blossomed and set full, but we had twenty-one days of continuous rain and they all dropped off." Now, during that twenty-one days was the most favorable time possible for the growth of fungi. Did it not attack and destroy the fruit, and cause it to drop? The damper and more rainy the weather in May and early June, the more urgent the necessity for spraying. We sprayed many days in a fine drizzling rain the past season.

No other persons in this vicinity sprayed at all with Bordeaux, and we have no knowledge of any orchard in this vicinity which has half a crop; many have very much less.

We keep our orchards in clean culture.

L. J. Groman

W. T. Mann, Barkers, Niagara Co. (see frontispiece).

My orchard was planted about 1870 to '73, and contains eighty-eight trees, eighty-five of which are bearing. As the distance be-

tween them is only twenty-five by thirty feet the orchard occupies a little less than one and one-half acres. The soil varies from a clay loam to a sandy loam with a clay subsoil, and has sufficient irregularity of surface to afford good surface drainage. For perhaps ten or twelve years the young orchard was planted with hoed crops, and was then seeded and used for a number of years as a meadow. During the past three or four years it has been plowed and cultivated without cropping. All these years it has been occasionally fertilized with light dressings of barnyard manure. Since 1889 it has been sprayed annually with an insecticide, and since 1891 with a fungicide. With this treatment it has produced fair crops annually for several years.

During the past season it has been kept well cultivated, first by a shallow plowing and later by frequent working with a spring-tooth harrow until the burdened branches prevented further passage. Early last summer the orchard was fertilized with an application of 200 lbs. of sulphate of potash and 400 lbs. of fineground bone per acre, sowed with a grain drill. I find by my records that the orchard was first sprayed May 5th with the Bordeaux mixture and Paris green. At that time an occasional King blossom was open. May 12th the orchard was in full bloom. May 15th "heavy frost, crust frozen on the surface of the soil." May 19th the bloom had mostly fallen, and three weeks of rainy weather began. The 25th scab spots began to show on the foliage, though none was then visible on the fruit. May 31st sprayed the orchard the second time. This spraying was greatly delayed by the heavy and long continued rains. June 9th sprayed the orchard the third time. Under date of June 18th I find this statement in my notes: "Corner orchard full crop, but many one-sided because of the scab."

The mixture used in all of our sprayings in this orchard was prepared by adding ten pounds of sulphate of copper, in solution in water to a hundred-gallon tank, then adding milk of lime until the test of ferrocyanide of potassium was satisfied, and then one-half pound of Paris green was added, after which the tank was filled with water. We used a power pump with two nozzles, a Vermorel for the lower branches, and a McGowen for the tops. After applying the spray to each side of each row, we crossed the rows. In this way we endeavored to reach all parts of the trees, but in this effort we were disappointed, as a careful examination just before the picking season showed. At that time many of the trees bore but little fruit in the interior, while the outer branches which received the spray, were certainly overloaded. The results have satisfied me that thorough work can be accomplished only with a hand pump.

As to the results for this season, I present the following table. It should be stated, however, that it was the off or non-bearing year for the Cranberry Pippin, and many of the Greenings, and the price quoted is simply the average price paid here in our local market for good fruit :

No. trees.	Variety.	No. of barrels.	Value at market price.
32,	Baldwin,	60,	\$90 00
23,	Greening,	32,	48.00
16,	King,	31,	46.50
10,	Cranberry Pippin,	8,	12.00
2,	Northern Spy,	7,	10.50
1,	Fallawater.	1,	1.50
1,	Early Harvest,	1,	1.50
85,		140,	\$210.00
	Culls and windfalls, 99 bushels,		19.80
		\$229.80	

The quality of this fruit is especially worthy of mention. In the case of the Baldwins a record was kept of the quantity of culls obtained from the picked fruit. In one lot of nineteen barrels of first grade fruit, two bushel crates held all the culls. In case of another lot of fifteen barrels, one bushel crate held all the culls, and in the whole lot there were but eight bushels. In order to show the quality of the first grade fruit, I submit a copy of the statement of the buyer :

"*Dear Sir :* We are pleased to state that the Baldwin apples which we purchased from you and which you stated were from a well sprayed orchard were the finest lot which we have seen this year. We noticed no wormy specimens, and but comparatively little injury from the scab. E. L. ELLIS."

Now while this crop may not be remarkable for yield considering the amount of land, or number of trees, still, when we consider the size of the trees, the general failure of apples in this section, (the crop of the county being estimated at only twenty per cent.) and the quality of the fruit, the result is certainly very satisfactory.

H. L. Brown

H. L. Brown, Carlton, Orleans Co.

As near as I can get at it my orchard is about 30 years old. It contains 146 trees. We barreled 898 bbls. from the orchard this

year, 749 firsts and 149 seconds. I have had the management of the orchard ever since 1889. That spring it was top dressed with yard manure and pastured to sheep. We got no apples. In 1890 pastured again, and no apples. In 1891 pastured and picked 100 bbls. In 1892 pastured and picked about 75 bbls. of poor apples. It was top dressed in 1893 with yard manure, and pastured. We shook off about 200 bushels of drying apples. In the late fall of 1893 and the winter of 1894, we gave the orchard a heavy dressing of stable manure of the best quality. In the spring of 1894, we gave the orchard a very severe pruning and began spraying. In this work we followed the directions of Cornell Bulletin No. 60. We used the

8. *Saved by spraying. The picture shows the props which were used to hold up the trees. H. L. Brown.*



Bordeaux exclusively. I cannot give the exact date of each spraying. The first one was made early in May, before any leaves started. The next one came just as the buds began to show a little red color. The third one was made after the blossoms had fallen and fruit set. Part of the orchard was sprayed the fourth time, the very last of June, and I could see a marked difference in favor of four sprayings.

The general result has been everything I could ask. I sold apples for \$2.12½ and our neighbors could get only \$1.50 to \$1.75.



G. H. Bradley & Son, Lake Road, Niagara Co.

Our Duchess of Oldenburg orchard is 17 years old and has 375 trees which produced this year 900 bbl. firsts and windfalls, which netted us \$2100. We sprayed 3 times with Paris green. The orchard has been cultivated and fertilized with stable manure heavily for the last four or five years. There were almost no No. 2 apples. We picked 200 bbls. at one picking and had only 3 bbls. of No. 2.

Our Twenty Ounce orchard yielded at the rate of \$400 per acre, treatment same as Duchess, except that it was sprayed 7 times with Paris green and Bordeaux mixture. Baldwins and Kings yielded at the rate of \$150 per acre, and the quality was No. 1. They were also sprayed and manured.

Duchess sold for \$2.75 per bbl.

Twenty Ounce sold for \$2.35 per bbl.

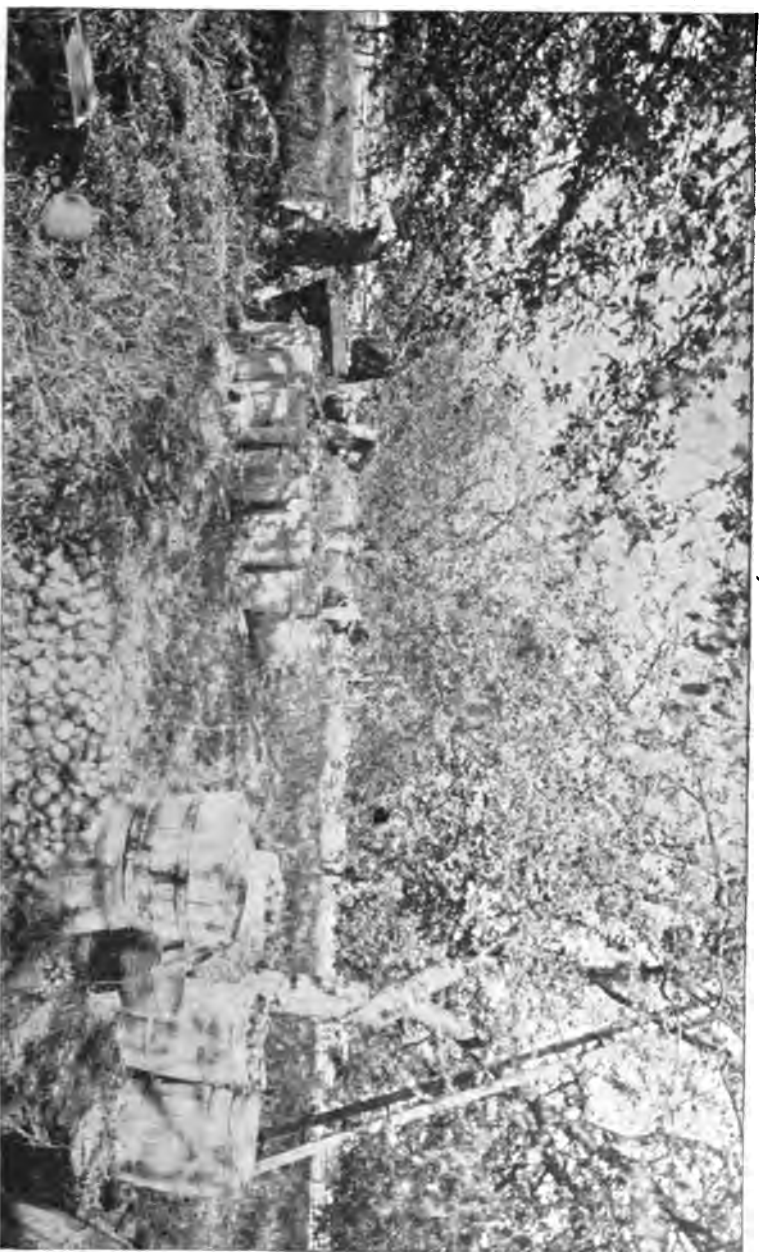
Baldwins and Kings sold for \$2.00 per bbl.



Albert Wood, Carlton, Orleans Co. (See frontispiece).*

My orchard covers about twenty-five acres and was set in the spring of 1860. The land is moderately rolling, descending toward the north, and is well underdrained with stone trenches. The soil is a deep, gravelly loam, and the orchard bore fairly

* Mr. Wood's account was also presented to the Western New York Horticultural Society, Jan. 23, 1895, but it was first prepared for this bulletin.



9. *The reward of tillage, feeding and spraying.* G. H. Bradley & Son. (See page 26.)

well up to eight years ago. Six years ago I became convinced that, like all orchards of early setting, the trees were altogether too thick; they interlocked, and the red apples, such as Baldwins, were, as you might say, growing white from lack of sun and air; the ground was covered with moss, and, as well as the trees, had become unproductive. I had one half of the orchard cut down diagonally, leaving the remaining trees standing in diamond order, twenty-four trees to the acre. As a result of this thinning out, the ground lost its sourness and became covered with grass—in fact the change was as great as in a cup of black coffee after receiving cream and sugar. I wish to say, for the benefit of my brother fruit growers, that the butts of those trees were sold for fifty-five dollars per thousand to Henry Disston & Sons, saw manufacturers of Philadelphia, yielding me about six hundred dollars. But all this thinning out, with good culture and heavy manuring added, did not rid this orchard of the apple scab fungus. The foliage was rusty and the apples scabby every year, though there was a fairly good yield of inferior fruit. In January, 1893, according to my custom, I visited the Western New York Horticultural Society, and made myself thoroughly acquainted with the scab fungus through information received, and carefully noting the valuable suggestions in our excellent Experiment Station bulletins. In the following spring, I selected two Baldwin trees which bloomed fairly well, and gave them three thorough sprayings with the Bordeaux mixture. These two trees gave me a heavy crop of first class apples; while the fruit in the balance of the orchard was so scabby that the bulk of it was sent to the dry house, and those I packed were by no means of first quality. This experiment thoroughly converted me to the importance of spraying orchards for profit; and in the spring of 1894 I set to work with all the force and confidence which I every year expend in raising fifty to seventy-five acres of beans. I will now give the results of seven tests of spraying.

First Test.—On April 23, 1894, I commenced with the Bordeaux mixture on my apple orchard (twenty pounds sulphate of copper and four pails milk of lime to one hundred and fifty gallons of water) just as the buds began to swell. Greening, Baldwin, King, Twenty Ounce, Talman Sweet, Strawberry—in fact all my varieties were treated in the same manner and at the same time. May 1st. I began a second spraying, using the same formula with the exception of one pound of Paris green added. The buds were at this time about as large as a robin's egg. Before this spraying was finished, the buds opened somewhat, showing the flower. Following this spraying, we had a very heavy rainfall—over five inches on the level—but the lime and the sulphate of copper still adhered to the foliage and was plainly

visible, which gave me great confidence that after the mixture was once set it would remain and do its work. The third spraying was done with the same mixture as the second, and when the apples were on an average about one half inch in diameter, although some were larger. They had a healthy stem and satisfied me they had come to stay ; there were fourteen large Baldwin trees not sprayed, and these were dropping fruit, and the stems of what remained on the trees were turning yellow and ready to fall.

Second Test.—My pear orchard was treated the same way as my apple orchard. In both orchards the sprayed trees were heavily loaded. Indeed, there was hardly a tree in either orchard that had not one or more limbs broken by the weight of the fruit. The foliage was dark, rich, rank and heavy, a wonder to the whole neighborhood, especially the perfect fruit growing on the inside of the trees on the small fruit spurs. In fact, I made a standing offer to my city friends and to my neighbors, that if they could find a wormy or a scabby apple on any tree that had been treated, I would make them a present of their winter supply of fruit. When we picked the crop, the fourteen trees not treated had no apples on the inside ; the foliage was rusty and dropping ; there were some apples on the top branches, but I gathered only thirty-five barrels from fourteen trees when I ought to have had one hundred and thirty-five. The picking began October 1st. The apples were placed in packages and remained thirty-four days after being barreled. The buyers, as all know, require close packing ; and I found the thirty-five barrels from fourteen unsprayed trees had shrunk five barrels, while those from the sprayed trees (two thousand four hundred barrels) had not shrunk five in two thousand. The crop was sold for three shillings per barrel more than the average market price. The two trees sprayed in 1893, and again this year, also bore a few apples, but every apple was perfect, showing that by a proper use of the Bordeaux mixture we can raise apples in the off year.

Third Test.—I had one Strawberry tree from which I had not had a perfect apple in nine years. I sprayed it. This was its off year (1894) but every apple was large and perfect. The same can be said of the old fashioned Holland Pippin.

Fourth Test.—One tree of my Kings was left untreated. The apples were worthless, while those treated gave results equal to the best, though a little undersized, owing to the heavy crop.

Fifth Test.—One tree of Twenty Ounce was left untreated. The apples were covered with scabs and checks, making them entirely worthless, while those on the treated trees were extra large, and smooth as glass.

Sixth Test.—One tree of Roxbury Russet was left unsprayed. I can safely say that three-fourths of the apples were fit only for cider, the balance only passable. The Russets from the treated trees were not so smooth as the other varieties. I find them to be more susceptible to the scab than other varieties, and have concluded they should be sprayed five times.

Seventh Test.—I have one old standard pear tree, 25 feet high, of the old White Doyenne or Virgalieu variety. I have not had a single perfect pear from this tree in twenty-five years. This year, after being treated according to the Cornell spray calendar, it was loaded, and there was not one imperfect pear on the tree. I called the especial attention of Professor Bailey to that tree, and he conceded that he could not find a single imperfect specimen upon it. Over fifty other fruit growers who visited me during the season gave the same testimony.

I can safely say that in size, quantity, quality and keeping properties, these tests show at least ninety per cent. in favor of spraying. In one block of twenty-five hundred dwarf Duchess pear trees, set four years ago, I sprayed twice, leaving one row. In riding along the road during the growing season any one could see a difference in the foliage. That on the unsprayed trees fell early, while that on the treated trees held on till after the second hard freeze; and the trees showed a growth from a fourth to a third more than the unsprayed.

In another block of about the same number, set at the same time (principally Kieffer, standard and dwarf Anjou) treated in the same manner, there were similar results. The same can be said of a block of Orange quince, set at the same time. In fact, all varieties of fruit gave marked results. No description can do injustice to the effect of spraying my cherries and plums. The latter astonished all who saw them. The foliage on my Fay currant bushes was a thing of beauty. We gathered fruit hidden under the rank growth, twenty days after the unsprayed bushes were entirely bare. I wish to say to the fruit growers of western New York, that we can raise fruit as in the old times. Of course, in case of storms or heavy cold rains at the time when the flower is being fertilized, we are liable to loss, as the rains wash off the pollen. My apple orchard is now in grass, pastured very close with sheep, which I consider the right kind of treatment, to prevent the grass from growing so high as to act as a pump on the soil. The Bordeaux mixture must be applied in the form of a vapor,* and the proper appliances must be employed, proper nozzles and proper spraying machines, to insure success. For a large orchard the pump should be strong enough to carry two leads of

*That is, a fine strong spray. Mr. Wood used the McGowen nozzle. L.H.B.

hose with four nozzles, that is, two on each lead of hose with Y attachment. Three of my neighbors, Harry Brown, [see page 26] George D. Simpson and Frank Cohoon, can furnish equally strong testimony regarding the benefits of spraying their orchards. The quantity and quality of their fruit and prices received were far in advance of those who failed to treat their orchards.

Albert Wood

A Michigan Experiment in Renovating an Old Orchard.

The first investigation which I made of the reasons for the failure of the apple crop was inaugurated in 1885 at the Michigan Agricultural College. At this time, the Paris green spray was in its experimental stage, and Bordeaux mixture had not been used upon orchards. The following account was published at the time,* but as it was before the establishment of the general experiment stations, the experiment attracted little attention. There is nothing unusual in the experiment, and it is inserted here chiefly for the purpose of illustrating the fact that treatment for the renovating of an old orchard must be continued three or four years before great increase in the crop is to be expected.

"The college apple orchard, originally comprising about nine acres, was set in 1858. The original plantings were mostly Northern Spy, Baldwin, Talman Sweet and Seek-no-further. The soil is a strong sandy loam, in some parts inclining to be cold and wet. The orchard has received various treatments. For nearly ten years, beginning about 1873, careful and valuable experiments in culture were carried on by Dr. W. J. Beal. In recent years the orchard has received less attention, being allowed to stand in sod. It has borne very few good crops, even from the first. In 1885, when the immediate control of the orchard passed into the hands of the writer, the trees presented a discouraging appearance. The previous hard winter had destroyed many of the largest trees on the lower land. Most of these trees were Baldwins, Greenings and Fall Jennettings. In fact, there is only one Baldwin left in the orchard and but two or three Greenings and Jennettings, and all are feeble. Many or all of these trees had been injured by a hard winter some ten or twelve years before. The remaining trees of the orchard, apparently from neglect in culture, were feeble during the year, the leaves presenting a yellow and sickly appearance. Many of them appeared to be dying. All the trees were very much stunted, there not being enough last year's wood on most of them to furnish even a few good scions. Many of the main limbs had died back from the ends and the dead portions

*Bull 31, Agric. College of Mich. 82 (1887).

were conspicuous in every direction. The trunks were often mossy and rough. The tops were for the most part very thick and low, so that no attempt at thorough culture could be made. Most of the orchard lay in a dense June grass turf. In short, the orchard was in so poor condition that several careful farmers recommended that it be cut down.

"The first work of renovation was to prune the trees. This was done vigorously in May, 1885, the tops being made high enough in every instance to allow the passage of a horse in harness. All limbs, irrespective of size, which would interfere seriously with plowing and cultivating, were removed. At the same time the tops of the trees were thinned considerably, though not to such an extent as to allow the sun to beat continuously upon the main branches. The trunks and main limbs, so far as a man could reach, were scraped, all the loose bark and "moss" being removed. This scraping was performed solely for the purpose of making the trees look better. . . . As soon as the pruning was accomplished and the great quantity of brush removed, the ground was plowed, and plowed as deeply as possible. To be sure roots were broken, but this did no harm. The ground was cultivated at intervals with the spring-tooth harrow, and in August a second plowing, in the opposite direction, was made. No crops were planted. There was no effect produced upon the trees that year. The season's growth, if any, was well under way when the first plowing was made. The leaves continued yellow, and fell very early, as usual.

"In 1886 the same treatment was repeated. Nearly as much pruning was done as in the previous year, this time, of course, entirely in the tops of the trees. Care was exercised, however, not to prune the tops so thin that the large limbs would be injured by the sun. The trees early showed signs of improvement. Although the summer was dry, the growth on all the trees was good and the leaves assumed a dark, vigorous color, and remained very late upon the trees. So marked was the improvement in the orchard that it was a subject of common remark. A fair crop of apples, some 300 bushels, was also gathered.

"In the spring of 1887 the orchard was again plowed, deeply as always before, and the sod was removed from all the trees by hand. The tops are now so high that the plow turned over nearly all the sod. The ground was now in good heart. The trees set very full of fruit, and no pruning was attempted. Although the trees have borne a heavy crop, and the season has been one of almost unprecedented drouth, the growth has been heavy. The bearing trees are 140 in number, of which less than 100—all Northern Spy—are a prolific variety and produced apples which find a demand in market. There are a number of Sweet Romanites and others which cannot be expected to return a profitable crop. The sales for the year have been as follows:

274 bbls. No. 1 (822 bu.) @ \$1 35	-	-	-	\$369 90
100 bbls. No. 2 (300 bu.) @ 75	-	-	-	75 00
60 bu. @ \$0 25	-	-	-	15 00
100 bu. @ 30	-	-	-	30 00
220 bu. made into cider @ \$0 20	-	-	-	44 00
300 bu. cider apples @ \$0 05	-	-	-	15 00
1802 bu.	-	-	-	\$548 90

"The reason for the great proportion of cider apples is the heavy crop and the drouth, rendering it impossible for all the fruit to mature. Thinning would probably have paid. The crop was remarkably free from worms. Old apple buyers declared that they had never seen so few wormy apples in a crop. This freedom from insects was due to sprayings of Paris green. . . . We used a half-pound of Paris green to a kerosene barrel of water. In one instance we used three fourths of a pound, but the liquid injured the foliage.

"Permanent sod [without fertilizing] is an injury to the orchard. This has been proved in the experience of nearly every successful orchardist. It is forcibly illustrated in the instance of the old College orchard. In the earlier experiments conducted by Dr. Beal the same fact was emphasized. For some years he kept a part of the trees in sod, others were cultivated thoroughly, while still others were cultivated at varying distances from the body of the tree. Even as early as 1874 he found that "trees in grass made less growth, looked yellow in foliage, and bore smaller fruit and apparently less of it." In 1875 he observed that "the evidences looked more and more strongly every year against the propriety of leaving trees, in our section, in grass. They have stood the severe winters no better; they have borne no better; the apples are smaller; the trees grow more slowly; a greater proportion of trees have died than of those cultivated each year. So marked have been the results that we have plowed up about half that part of the orchard which was left in grass.' "

J. H. Bailey

SUMMARY.

Till.

Feed.

Prune.

Spray.

POMOLOGICAL PUBLICATIONS OF CORNELL UNIVERSITY EXPERIMENT STATION.

Those bulletins which are out of print are marked with an asterisk. Articles which are published along with other matter, in miscellaneous bulletins, are placed in parenthesis.

- *Bulletin 3 (1888). (On the Destruction of the Plum Curculio by Poisons).
- *— 9 (1889). Windbreaks in their Relation to Fruit Growing.
- *—14 (1889). Strawberry Leaf-Blight.
- *—15 (1889). (Anthracnose of Currants. Leaf-Blight of Quince and Pear. The Apple-Tree Tent Caterpillar. The Crandall Currant).
- *—18 (1890). Experiences in Spraying.
- *—19 (1890). Report upon the Condition of Fruit Growing in western New York.
- *—23 (1890). Insects Injurious to Fruit.
- *—25 (1890). (The Peach Yellows).
- *—34 (1891). Dewberries.
- *—35 (1891). Combination of Fungicides and Insecticides.
- 38 (1892). The Cultivated Native Plums and Cherries.
- *—44 (1892). Pear-Tree Psylla.
- 46 (1892). Mulberries.
- *—48 (1892). Spraying Apple Orchards in a Wet Season.
- 49 (1892). (The Black Peach Aphis. Fertilizers for Grape Cuttings. Black-Knot of the Plum and Cherry. The Vetch or Tare as an Orchard Plant).
- *—50 (1893). The Bud Moth.
- *—51 (1893). Four New Types of Fruits.—*Prunus Simonii*. Wineberry. Crandall Currant. Dwarf Juneberry.
- *—57 (1893). Raspberries and Blackberries.
- 58 (1893). The Four-lined Leaf-Bug.
- 59 (1893). Does Mulching Retard the Maturity of Fruits?
- *—60 (1893). The Spraying of Orchards.
- 61 (1893). (Edema of Apple Trees. The Pear Leaf Blister. Orchard Covers,—Vetch, Cow Peas, Peas, etc. Labels.)
- 62 (1894). The Japanese Plums in North America.
- 69 (1894). Hints on the Planting of Orchards.
- 70 (1894). The Native Dwarf Cherries.
- 71 (1894). Apricot Growing in western New York.
- 72 (1894). The Cultivation of Orchards.
- 73 (1894). Leaf Curl and Plum Pockets.
- 74 (1894). Impressions of the Peach Industry of western New York.
- 75 (1894). Peach Yellows.
- 76 (1894). Some Grape Troubles in western New York.
- 77 (1894). The Grafting of Grapes.
- 79 (1894). Varieties and Leaf-Blight of the Strawberry.
- 80 (1894). The Quince in western New York.
- 81 (1894). Black-Knot of Plums and Cherries, and Methods of Treatment.
- 83 (1894). A Plum Scale in western New York.

630.679

N 7

C 8 el-

Bulletin 85.

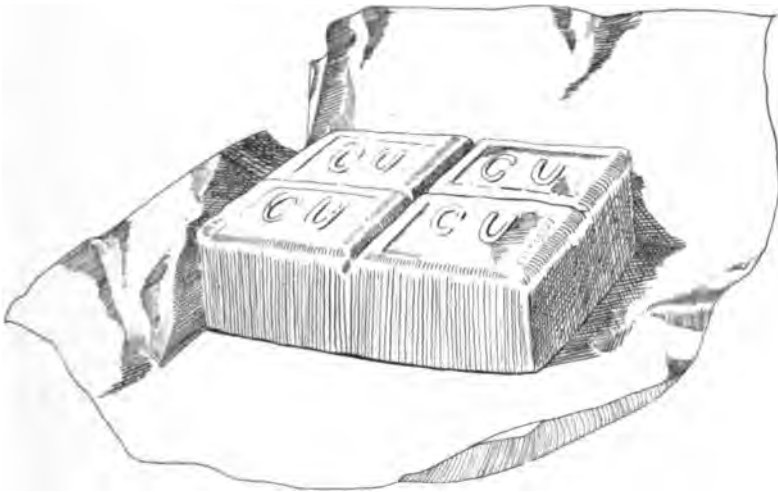
March, 1895.



Cornell University Agricultural Experiment Station.

AGRICULTURAL DIVISION.

WHEY BUTTER.



By H. H. WING.

PUBLISHED BY THE UNIVERSITY,

ITHACA, N. Y.

1895.

ORGANIZATION.

BOARD OF CONTROL:

THE TRUSTEES OF THE UNIVERSITY.

STATION COUNCIL.

President, JACOB GOULD SCHURMAN.

Hon. A. D. WHITE,	-	-	-	-	Trustee of the University.
Professor I. P. ROBERTS,	-	-	-	-	President State Agricultural Society.
Professor I. P. ROBERTS,	-	-	-	-	Agriculture.
Professor G. C. CALDWELL,	-	-	-	-	Chemistry.
Professor JAMES LAW,	-	-	-	-	Veterinary Science.
Professor A. N. PRENTISS,	-	-	-	-	Botany.
Professor J. H. COMSTOCK,	-	-	-	-	Entomology.
Professor L. H. BAILEY,	-	-	-	-	Horticulture.
Professor H. H. WING,	-	-	-	-	Dairy Husbandry.
Professor G. F. ATKINSON,	-	-	-	-	Cryptogamic Botany.

OFFICERS OF THE STATION.

I. P. ROBERTS,	-	-	-	-	-	Director.
E. L. WILLIAMS,	-	-	-	-	-	Treasurer.
H. W. SMITH,	-	-	-	-	-	Clerk.

ASSISTANTS.

M. V. SLINGERLAND,	-	-	-	-	-	Entomology.
GEO. C. WATSON,	-	-	-	-	-	Agriculture.
G. W. CAVANAUGH,	-	-	-	-	-	Chemistry.
E. G. LODERMAN,	-	-	-	-	-	Horticulture.
MICHAEL BARKER,	-	-	-	-	-	Horticulture.

Office of the Director, 20 Morrill Hall.

Those desiring this Bulletin sent to friends will please send us the names of the parties.

BULLETINS OF 1895.

84. The Recent Apple Failures in western New York.
85. Whey Butter.

WHEY BUTTER.

In the process of cheese making a small percentage of fat escapes in the whey. This fat is lost except in so far as it adds a slightly increased feeding value to the whey. From some hints that we had received from Dr. S. M. Babcock of the Wisconsin Agricultural Experiment Station, we were led to believe that this fat could be utilized in the form of commercial butter. Partly with the purpose of making some investigations into this matter and partly to afford our students additional practice in running the separators, we determined at the beginning of the Short Dairy Course term of 1895 to run the whey through the separators, and if possible to make butter of the fat that we were thus enabled to secure. Accordingly January 18th, 1895, we began to run the whey from the cheese making regularly through the separators and we have been successful in securing a large proportion of the fat in the whey in the form of commercial butter of good quality. This butter has been scarcely, if any, inferior to that made from cream, separated from whole milk and it has been printed and sold in the same market with our best butter. The details of the various separations and churnings are shown in the Table below.

This work has been done with the coöperation of Mr. W. W. Hall, Instructor in Cheese Making, and Mr. Jared Van Wagenen, Jr., Instructor in Butter Making. The details of the work were almost entirely in their hands and to them most of the credit of the work is due.

It will be seen that upon the average we have been able to secure 2.57 pounds of butter from each 1000 pounds of whey and that the whey has contained upon the average .25 of 1 per cent. of fat, showing that we have recovered in the form of butter nearly all of the fat in the whey.

In only a few details does the manufacture of whey butter differ from ordinary butter making.

On account of the small percentage of fat in the whey it was found to be impracticable to secure at one separation a cream

thick enough for best results without churning it more or less in the separator. In order to overcome this the whey was put through the separator in the same way milk would have been and about one-tenth the whole bulk taken from the cream outlet. This was found to contain on the average from 2 per cent. to 5 per cent. of fat or to be of nearly the same fat content as ordinary milk. This so-called "first cream" was run through the separator a second time, and in this way the cream condensed to the proper consistency for churning. In running the Danish-Weston machine, this was not found to be necessary. The Danish-Weston machine is provided with a contrivance whereby the proportional flow from the skim milk and cream outlets can be controlled at will and in running the whey through this machine it was found entirely feasible to shut off the cream outlet entirely until a sufficient amount of cream had gathered in the center of the bowl, when by turning in the skim milk point this cream could be thrown out, and after being so removed the skim milk point could be thrown back again until a second portion of the cream had gathered in the center of the bowl. In this way we were enabled to get a clean separation and cream of good consistency in one operation.

In all of our experiments the whey was run through the separator immediately after it was drawn and before it had cooled down. It was at this stage, of course, slightly acid and the resulting cream was in good condition to churn at once after being reduced to the proper temperature. We have had no difficulty, however, so far as the flavor of the butter was concerned in holding the whey 24 or even 48 hours in some cases, but would strongly recommend that the whey cream be churned as soon as convenient after separation. In one case where it was attempted to hold the whey 48 hours before separating, the development of lactic acid went so far that the flavor of the butter was spoiled. The practical point seems to be that the whey should be separated at once and where possible the cream churned quickly, and preferably in any case the whey cream should not be held more than 24 hours.

The cream from the whey, containing as it does, very little casein, was very easily, quickly and completely churned at a low temperature. The most complete churning was obtained when

the churn was started at a temperature from 48° F. to 54° F., the time required in most cases being less than 20 minutes.

In regard to the quality of butter ; as before stated butter made from the whey has gone into the same market as the butter made in the ordinary way. Good judges who have seen the two kinds of butter side by side have been in some cases unable to detect which was made from whey and which from cream. In other cases slight inferiority in texture and flavor have been noticed in the whey butter. That it is possible to make butter of good commercial quality we have clearly shown. Whether or not it can be done at a profit, is the practical question for the ordinary factoryman.

In order to enable the ordinary factory to utilize the fat wasted in this way, it would be necessary to provide storage capacity for a large part of the whey produced in any given day, and a centrifugal separator, churn and butter worker. In cases where more than one vat of milk is made up, by so arranging the work that the whey would be drawn from the vats at different times, it would not be necessary to provide so much storage, for the separator could be started as soon as the first whey was drawn and much of the whey could be gotten out of the way before the last vat would be ready. Most factories have the necessary steam power to run such a separator.

The manufacture of butter from the whey will not ordinarily require much increased labor. The whey can be run through the separator at the same time that the latter part of the cheese making process is going on and the churning will take but a small amount of time and labor. The additional items of expense will be the storage capacity for the whey and the separator. How much this saving might be made to the farmers of this state is shown by the following calculation :

According to the returns made to the Commissioner of Agriculture, there were made in the state of New York in 1892, 130,991,310 pounds of cheese. Estimating that for each pound of cheese there would be $8\frac{1}{2}$ pounds of whey we should have a total of 1,113,426,135 pounds of whey produced in the state. Our whey has contained upon the average .25 of 1 per cent., but our cheese is made in small quantities with special pains to prevent

loss of fat in the whey, and the percentage of fat in our whey is undoubtedly smaller than that of the state at large. In Bulletin 65 of the New York Experiment Station, Dr. L. L. Van Slyke gives the average of a large number of analyses of whey made by him during the season of 1893. This work represents analyses of whey made at 50 different factories in 8 counties of the state, extending from April to October, and the average of the whole shows .39 of one per cent. of fat in the whey. Assuming this to be a fair average of the percentage of fat in all the whey produced in the state, we should have 4,342,362 pounds of fat lost in the whey. Allowing that the butter contained 85 per cent. of fat and providing for all mechanical losses in the manufacture, we should make from this amount of fat 4,776,598 pounds of butter, which at 20 cents per pound would be worth \$995,319, or about 50 cents for each cow in the state.

In nearly all of the factories in the state this butter would find a home market among the patrons of the factory so that expense of packages and marketing need not be taken into account and the saving would be a clear one to the patrons.

HENRY H. WING.

630.679

N7
C8eb

Bulletin 86.

March 18



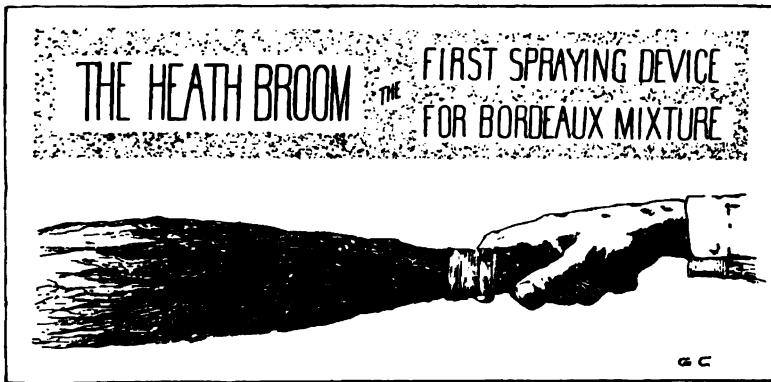
Cornell University Agricultural Experiment Station.

HORTICULTURAL DIVISION.

THE

Spraying of Orchards

APPLES, QUINCES, PLUMS.



By E. G. LODEMAN.

PUBLISHED BY THE UNIVERSITY,

ITHACA, N. Y.

1895.

ORGANIZATION.

BOARD OF CONTROL:

THE TRUSTEES OF THE UNIVERSITY.

STATION COUNCIL.

President, JACOB GOULD SCHURMAN.

Hon. A. D. WHITE,	-	-	-	-	Trustee of the University.
Professor I. P. ROBERTS,	-	-	-	-	President State Agricultural Society.
Professor I. P. ROBERTS,	-	-	-	-	Agriculture.
Professor G. C. CALDWELL,	-	-	-	-	Chemistry
Professor JAMES LAW,	-	-	-	-	Veterinary Science.
Professor A. N. PRENTISS,	-	-	-	-	Botany.
Professor J. H. COMSTOCK,	-	-	-	-	Entomology.
Professor L. H. BAILEY,	-	-	-	-	Horticulture.
Professor H. H. WING,	-	-	-	-	Dairy Husbandry
Professor G. F. ATKINSON,	-	-	-	-	Cryptogamic Botany.

OFFICERS OF THE STATION.

I. P. ROBERTS,	-	-	-	-	-	Director.
E. L. WILLIAMS,	-	-	-	-	-	Treasurer.
H. W. SMITH,	-	-	-	-	-	Clerk.

ASSISTANTS.

M. V. SLINGERLAND,	-	-	-	-	-	Entomology.
GEO. C. WATSON,	-	-	-	-	-	Agriculture.
G. W. CAVANAUGH,	-	-	-	-	-	Chemistry.
E. G. LODEMAN,	-	-	-	-	-	Horticulture.
MICHAEL BARKER,	-	-	-	-	-	Horticulture.

Office of the Director, 20 Morrill Hall.

Those desiring this Bulletin sent to friends will please send us the names of the parties.

BULLETINS OF 1895.

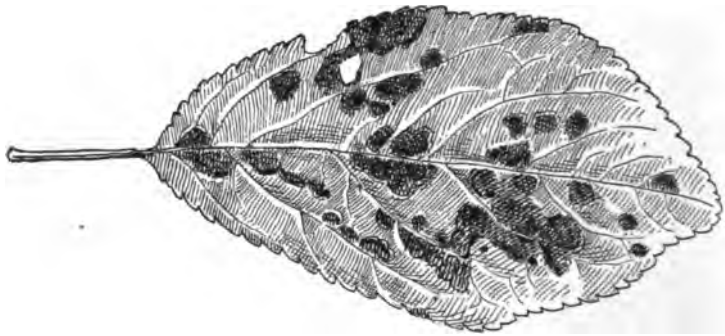
- 84. The Recent Apple Failures in western New York.
- 85. Whey Butter.
- 86. Spraying of Orchards.

CORNELL UNIVERSITY, ITHACA, N. Y., Mar. 1, 1895.

THE HONORABLE COMMISSIONER OF AGRICULTURE, ALBANY.

Sir: The following sketch of experiments in spraying orchards is submitted for publication under Section 87, Chapter 675, Laws of 1894. This bulletin may be considered to be a complement to No. 84, upon Apple Failures in Western New York. The general conclusions as to the fundamental causes of the recent failures of apples are essentially alike in the two bulletins, but they were arrived at independently by Mr. Lodeman and myself. It is now established that spraying with Paris green and Bordeaux mixture is often capable of rescuing a crop of apples and other fruits from the ravages of insects and fungi; but it is equally well established that spraying sometimes avails little. In other words, some of the failures of orchards to bear are due to insects and diseases, and other failures are due to causes which lie back of these attacks, probably to lack of available food supply. The inference is plain: orchards should be both fed and sprayed.

L. H. BAILEY.



10. *Plum leaf injured by fungus. (Page 70.)*



11. *Rotting of plums (page 70). The upper fruit-spur has been killed by the fungus*

THE SPRAYING OF ORCHARDS.

PART I.—NOTES ON THE SPRAYING OF APPLE ORCHARDS. (pp. 47 to 63.)

AT CORNELL. (pp. 47 to 64.)



MOST of the experiments made by the Cornell Experiment Station during the past season on the spraying of apples were conducted in the orchard of John J. McGowen, who again kindly placed his trees at our disposal. The orchard has now been treated by this station for three years, and it offers in several respects an excellent field for work of this character. In a previous bulletin* a full description of the orchard has been given, so that

* Cornell Agric. Exp. Sta. Bull. 60, p. 257.

12.--Pear killed by Bordeaux mixture.

all the conditions under which the experiments were carried on might be understood. Brief descriptions of the apple-scab and of the codlin-moth have also been published.† These two pests are the most serious ones against which the apple growers of this vicinity have to contend, and it has been found that by keeping them well under control the foliage and the fruit of the trees remain almost perfectly healthy throughout the season.

But the question is constantly before us as to how we can best control these two enemies of the apple grower. The present methods employed are in a great many ways unsatisfactory. The labor of making the application is difficult and unpleasant; the best time to spray is still a matter of doubt; the amount of liquid to use, the best methods of preparing it, and a host of other unsolved problems are continually arising and demanding answers. These cannot be definitely given when based on the work of only one season. One point and then another must be carefully studied, and the greater the delay in coming to a final conclusion, the greater should be its accuracy.

The machinery.—The selection of spraying machinery has proved to be somewhat unsatisfactory. The pumps which have given the best satisfaction are hand pumps constructed practically upon the model of Gould's "Standard," Fig. 905, of their catalogue. Nearly every pump manufacturer makes this style of pump and I have still to learn that one is any better than another. These pumps are comparatively cheap, they are very powerful and durable. Several pumps, smaller as well as larger ones, have been tried at this Station, but the above type has proved to be the least unsatisfactory. The one used has the serious objection, especially when much work is to be done, of being too small.

This fact has led us to try horse-power sprayers in apple orchards. Every man who sprays will welcome with delight any kind of a machine which will give the horse a chance to do the pumping instead of himself, and his delight will probably increase directly in proportion to the amount of spraying he has done in the past. With hope in our hearts we wrote to the Field Force Pump Co. of Lockport, N. Y., and this firm kindly sent us one of their machines for trial. It was taken to an orchard and thor-

† *Ibid.* Bulletin 48, p. 266, *et seq.*

oughly tested until all present were satisfied as to the capabilities of the machine. It worked perfectly, and in fact has done so throughout the year, but from the present light we have upon spraying matters it did not answer the purpose for bearing apple



13.—*Serviceable spray outfit for light work.*

trees from twenty-five to thirty years of age. The two objections found against it were that it did not throw enough liquid to cover a tree as thoroughly as was desired, and it did not throw the spray far enough for our purpose, although several nozzles were tried. In the vineyard, however, the machine did admirable work and

the sprayed vines yielded an almost perfect crop of fruit. It can also be used to advantage in spraying potatoes and other low growing crops, but for orchards this class of machines is as yet of doubtful value. The hand pump has the great advantage of allowing the operator to apply as much liquid as desired upon any given part of the tree. When such a pump is placed upon the side of a barrel, or on a tank having any desired capacity, and then placed on a wagon so that it can be hauled into the orchard, it makes a very serviceable outfit.

The nozzle which has been used during the past three years is the McGowen, manufactured by Mr. J. J. McGowen of this city. Most of the new nozzles have been tried, but none have yet been found equal to this one for spraying trees.

Figure 13 represents a very serviceable outfit when but little work is to be done, and no large plants are to be treated. The barrel holds about fifteen gallons. It can be drawn quite easily even upon soft ground for the tires of the wheels are broad. The pump is light and powerful, and has answered our purpose in many places.

The weather.—The past spring and summer were remarkable for the great extremes of rainfall and of drought. This applies particularly to the central New York region, for here the rain appears to have been more continuous than in other sections. The official record of the signal service station situated at Ithaca shows the following rainfall from April 1st to October 1st. The sign + denotes increase over the average, and the sign – a decrease.

Month.	April.	May.	June.	July.	August.	September.
Number of days during which rain fell	17	22	18	16	8	13
Total rainfall in inches	4.84	7.34	3.40	3.17	.059	5.17
Departure from the average for the month	+2.57	+3.10	-.36	-.71	-2.72	+1.23

It will be seen that April was an exceptionally wet month; May shows an increase over the average of 3.10 inches. The precipitation during the first week in June was also heavy. The records

show that during the first twenty-three days following May 16, rain fell during twenty-two, and twenty of these were consecutive. The unfavorable influence of such weather upon the successful spraying of apples and other fruits can only be realized when it is considered that there is probably the greatest need of the application at just this time.

An approximate schedule of the dates of spraying had been made out before the work was begun, and this schedule was followed as closely as possible. The applications were made some in sunshine, and some in rain, and at the time it seemed as if the liquids used were washed off as fast as they were put upon the trees. If the sprayed trees succeeded in becoming dry between the showers, that appeared to be all that could reasonably be asked.

During the last week in June the rainfall practically ceased, and then began a period of drought, more or less severe, which continued until early in September. This prevented the apples from attaining their normal size, but probably had little effect upon the severity of fungous and insect injuries. Not so with the early rains, however. Notes which were taken June 16, at the time of an application, show a very discouraging condition of foliage and fruit. The weather had been warm and moist and there had appeared, during the ten days previous to this time, a vigorous and quite general growth of the scab fungus. All the plots were attacked, and showed fruit that was already one-sided, and leaves that were more or less covered by the black, smoky patches of the parasite. In addition to this the young apples were rapidly falling from the trees, and what at first promised to be an abundant yield of fair fruit now seemed to indicate exactly the contrary. When the crop was harvested in September, the yield was indeed small, and it now remains to determine to what degree "the weather" was responsible for the loss.

The materials.—All the applications were made with the sole purpose of combatting fungi. The Bordeaux mixture was almost exclusively used, London purple, and the copper sulphate solution being the only other substances tested for this purpose. The trees sprayed with the mixture were not all treated alike as regards the amount of liquid used, the dates of applications, etc. The

Bordeaux mixture was, with two exceptions, always made according to the formula :

Copper sulphate,	6 pounds.
Quick lime,	4 "
Water,	45 gallons.

Upon two occasions, the mixture was prepared with the assistance of the ferrocyanide of potassium test. The value of this chemical in the preparation of the Bordeaux mixture lies in the fact that when in solution it will combine with dissolved salts of copper and form a compound having a deep reddish-brown color. When sufficient lime is added to the copper sulphate solution in making the Bordeaux mixture, several new compounds are formed, of which all that contain copper are practically insoluble. If an insufficient amount of lime is used, some of the copper salts remain in solution and the addition of a few drops of the ferrocyanide of potassium solution will produce the characteristic brown color in the mixture ; but as soon as enough lime is present to remove all dissolved copper, the test will cause no change to take place. This test solution may be made as follows :

Ferrocyanide of potassium (yellow prussiate of potash),	1 ounce.
Water, - - - - -	1 pint.

The chemical dissolves very readily, and is then ready for use.

When the Bordeaux mixture is prepared in this manner, it contains the smallest amount of lime necessary to satisfy all immediate chemical changes, and upon this fact rests the principal argument for the use of the method. The subject is more fully treated upon page 62.

The sulphate of copper solutions consisted of

Copper sulphate,	1 pound.
Water,	18 gallons.

This was applied as soon as the crystals were dissolved, but it was used only at the time of the first applications, before the buds had fully opened.

London purple was applied by using

London purple,	1 pound.
Air-slaked lime,	1 "
Water,	250 gallons.

The lime was added to prevent any caustic action of the poison.

The dates of the applications.—The trees were sprayed upon the following dates :

1. April 21. The buds had burst, but only the tips of the leaves could be seen.
2. May 7. Nearly one-fifth of the blossom buds had opened.
3. May 19. A few of the blossoms were still upon the trees.
4. May 31.
5. June 16.

It was the intention to make one more application about June 30, but at this time so much of the fungicide could still be seen upon the trees that further treatment was thought unnecessary. As but little rain fell during the next two months, the mixture could still be seen upon the leaves in September, so that even if another treatment had been made it would have been of little value.

The rust.—On June 29 the orchard was examined and a serious amount of rust was discovered. It was found that the Red Astrachan, Fallawater, and the King apples showed injured foliage and fruit, partly in consequence of the Bordeaux mixture which had previously been applied. Baldwins were not so seriously hurt, and Fall Pippin showed no trace of any such trouble upon the fruit. Here then was another difficulty, only traces of which had been noticed during the past year but which now appeared nearly as formidable as the scab or the codlin-moth. Upon the leaves, it appeared to show itself in the form of reddish-brown areas, generally quite small, and probably of minor importance as regards injury to the tree. Upon the fruit, the affected portions turned grayish-brown, and later in the season such portions were rough and appeared yellowish-brown in color. A microscopic examination of these injured tissues showed that the coloring matter normally present when the fruit is ripening was entirely wanting, and the walls of the cells that are situated under the epidermis or outer skin of the apple had become thickened and seemed to have acquired a corky texture. Any external irritation of the apple may cause such a formation, and it undoubtedly was so caused last spring. This subject is more fully discussed on page 62.

Grading the apples.—In 1893 the apples of this orchard were graded upon the following basis: "The amount of scab or other fungous injury upon an apple determined its grade, the injury done by worms being rather secondary, for the apples were comparatively little damaged by them." * In consequence of this standard it frequently became necessary to place a commercially first class apple into the second or possibly into the third grade. The orchard had been sprayed with arsenites so that the worms did not do any serious damage. This year, however, the worms were allowed to have everything their own way, for no applications were made which were designed to destroy them. All applications were made with the sole object of combatting the scab, and so in the final grading, insect injury, to whatever extent it may have taken place, did not prevent an apple from entering the first class. It was only on account of fungous injury that affected apples were removed. Since the apples were very wormy (see page 60) it made the first grade appear anything but fancy fruit, although the selection had been made in conformity to the principles laid down when the work was undertaken.

Another factor which rendered the grade more difficult was the rust, of which mention has already been made. In some cases it was practically impossible to determine whether a certain injury was caused wholly by scab, or by rust. It was too late in the season to tell accurately the cause of a blemish upon an apple. Fortunately such cases were not very common.

In order to simplify the table, the figures showing the number of apples in each grade represent what per cent. of the total yield of a plot the given grade formed. The trees bore a light crop, (see page 61), the Kings averaging scarcely three bushels per tree, while the Baldwins and the Fall Pippins bore less than two bushels each. Such a small yield was disappointing, for it is desirable to have as many apples as possible to get at the true value of an experiment. Nevertheless the figures given on the following pages are quite accurate. Some of the experiments made were solely for the purpose of verifying results which had

* Cornell Agric. Exp. Sta. Bull. 60, p. 264.

been attained here and at other stations, and with scarcely an exception the results have been practically the same as in past years when larger crops were borne. The King trees in particular were very uniform in this respect. Unfortunately, some of the trees of the other varieties bore hardly an apple and in such cases, of course, not even an approximate conclusion could be reached. On this account several experiments planned were without result. Those upon which reliance could be placed are given below.

The number of applications necessary.—The King trees selected for this experiment showed considerable difference in the quality of the fruit, as shown in the table. They were treated with the Bordeaux mixture and as nearly as possible the same amount of liquid was applied to each tree.

TABLE I.

Showing the value of varying numbers of applications.

Number of Applications.	First Class.	Second Class.	Third Class.
0	7	27	66
2	42	55	4
4	58	34	9
5	52	46	2

Probably the most interesting feature of the table is the effects produced by only two applications. These were made May 7 and May 19. The number of first class apples was increased from seven to forty-two per cent. while the third class fruit diminished from sixty-six to four per cent. The additional treatment given the other plants show still greater benefits but not in the same proportion.

The plot treated four times shows considerably more first class apples, and the apples of the second class were also decidedly less attacked by scab and were consequently more handsome. This lot also shows an increase in the third quality, yet this can scarcely be attributed to the spray which produced such favorable results in the plot treated but twice. The apples from the trees which were sprayed five times, all grades considered, were not much better than those receiving four treatments. This is practically the same result which was obtained last year* with this variety. The comparatively slight difference between the fruit treated twice and that treated four times suggests the use of

*Cornell Agric. Exp. Sta., Bull. 60, p. 267.

only three treatments, and if only this number had been made, it would in all probability have been sufficient. The other varieties treated in these plots did not yield sufficient fruit for safe comparison.

The two most important applications.—It has been shown in former bulletins from this station, as well as in those from other stations, that the most important treatments are those made in the spring. The use of only two applications has been followed by such good results with some varieties that this number seemed to be sufficient to control the apple-scab. But the best time for making these treatments cannot be stated unhesitatingly. Two applications were therefore made at different times to certain King and Baldwin trees to discover if possible which treatments were the most effective. Three plots, or divisions were made :

1. Two applications made before the blossoms open: April 21, copper sulphate solution; May 7, Bordeaux mixture.
2. One application made just before and one immediately after the blossoming of trees; May 7, and May 19, using Bordeaux mixture.
3. Two applications after the blossoming of the trees: May 19, and May 31, using Bordeaux mixture.

TABLE II.

Showing effect of two applications made at different times.

King.				Baldwin.		
Dates of applications.	First class.	Second class.	Third class.	First class.	Second class.	Third class.
None	7	27	66	7	20	73
April 21						
May 7	26	53	22	18	40	42
May 7						
May 19	42	55	4	35	35	17
May 19						
May 31	46	47	7	48	30	22

The yield from untreated trees is given in the adjoining table for comparison. The trees receiving the two earliest treatments were greatly benefited by them. The number of third class apples was reduced from 66 per cent. to 22 per cent. in the case of the King, and the Baldwin showed a reduction from 73 to 42. There was also a marked in-

crease in the number of first class and second class apples of both varieties.

Turning to the second division, those treated May 7 and May 17, we find that a still greater difference has been made by these two applications than by those of the first division. The King in particular shows this difference, there being only 4 third class apples, but 42 in the first class. The Baldwin also shows a marked improvement, but it is not so decided as in the case of the other variety.

The apples of the third division, do not differ much from those of the second. This is especially true of the King apples, there being a few more first quality fruits, but also more of the third grade. The Baldwins show a similar increase, but it is still more marked in the first class fruit. (See also p. 67, The Nixon orchard).

Having thus briefly considered the character of the fruit, it will be interesting to note which treatment has been followed by the best results. The first two applications did not produce the fairest fruit, while that of the second division, in the case of the King apples, was equal to any borne by the trees. The Baldwin also showed such an improvement that it will be safe to say the application made April 21 was not so valuable as that made May 7. In the third division the Baldwins show a still greater improvement, and it would appear from them that the treatments made May 19 and May 31 were the most valuable. Such may have been the case this season, but in 1892* it was found that when the first application was made as soon as the blossoms fell, the scab had already secured an entrance into the fruit and the foliage of the trees. Taking this fact into consideration, it would appear that the most important treatments for apple-scab† are those which are made just before the blossoms open and soon after they fall, this statement being, to a certain extent, dependent upon the season.

The amount of liquid to apply.—I have so often seen men spraying their trees with much less liquid than it has been our custom to apply that one part of the orchard was this year used to determine the effect of applying different amounts of the Bordeaux mixture. Six King trees, well grown, and nearly thirty years of age,

*Cornell Agric. Exp. Sta. Bull., 48, p. 269.

†The treatments to be made for the codlin-moth have been discussed in bulletin 60 of this Station.

were selected for the purpose. Two were treated with two gallons of the mixture at each application ; two with three gallons, and two with four gallons. Care was taken to distribute the smaller amounts of liquid as evenly as possible, so that it should not be applied in patches.

TABLE III.

Showing the value of different amounts of fungicide.

Gallons of Liquid.	First Class.	Second Class	Third Class.
0	7	27	66
2	39	53	8
3	48	47	5
4	49	46	5

The average of the check trees is here again used for comparison. The marked benefits derived by applying only two gallons are seen at a glance. The improvement is still greater where three have been used. Four gallons did not make sufficient difference, as shown by the table, to make the use of this amount desirable. Judging only from the table, therefore, it would appear that the proper amount of the Bordeaux mixture to use on trees of this size, provided the liquid is well distributed, is between two and three gallons.

But figures are not the most satisfactory things to deal with, especially when they refer to the grading of apples. The table does not show that the size, symmetry, and fairness, the rust of course excepted, increased almost directly in proportion to the amount of the mixture used. It does not show that the apples which received but two gallons at each application were only about two-thirds as large as those that were treated with four, yet such was the case, nor is the degree of insect injury hinted at. Nevertheless the apples which had been most thoroughly sprayed showed fewer insect injuries ; I refer particularly to those many kinds that are so commonly seen upon the surface of the apples, and not to the codlin-moth. This permitted a more regular growth to take place and the apples treated with four gallons of the Bordeaux were decidedly superior to those treated with only three. Although this result was entirely unlooked for, it was so evident that it could not escape notice. Now the question arises, does the Bordeaux mixture have any influence in keeping insects from fruit, or does it merely encourage growth ? The scab did not influence

this result, for it was upon the amount of scab present that the apples were graded.

The effect of former applications upon the crop of 1894.—It has been the custom to leave an additional check tree each year since work in the orchard began. There were three King trees left unsprayed this year; one had never received treatment, another had been sprayed in 1892 only, and the third in 1892 and again in 1893. The trees when sprayed had received liberal applications of the Bordeaux mixture.

TABLE IV.

Showing the effects of former applications of fungicides on the crop of 1894.

Treatment.	First class.	Second class.	Third class.	Amount yielded.
Never sprayed.....	6	26	68	1 bu.
Sprayed in 1892... ..	4	23	73	$\frac{1}{2}$ "
Sprayed in 1892, 1893	12	31	57	$1\frac{1}{4}$ "
Average.....	7	27	66	1.42 bu.

The table does not offer much hope to the lazy man, for the scab is nearly as abundant upon one plant as on another. There is some difference in favor of the tree which was treated twice but it is not great enough to encourage an apple grower to neglect the care

of his trees; yet one circumstance must be taken into consideration. These trees are situated in an orchard which is only partially well sprayed. There has not been a systematic effort to exterminate the disease upon the trees, which might make a greater difference than is shown by the table.

The early use of the copper sulphate solution is closely related to this subject. It may be possible to free the trees from the scab fungus before the buds break by destroying it so early in the season, but the results obtained in the orchard this year do not encourage the plan. The proximity of untreated trees probably exerted an unfavorable influence. Yet what orchard, even if entirely so treated, is so isolated that it may not be infected from another in the neighborhood? Until more work has been done, it

seems advisable to spray the young fruit as suggested by Table II, on page 561.

London purple as a fungicide—Since the establishment of the fact that Paris green possesses considerable value as a fungicide, its use upon trees which are being treated for fungi, to determine the comparative value of different materials, is not advisable. London purple was this year applied to one-half of a Fall Pippin tree to discover if the scab would be affected by the applications. Five treatments were made. This variety of apple is generally very much injured by scab, but it may also be protected quite easily by the use of proper fungicides. Some trees to which the Bordeaux mixture had been applied produced very large and fair fruit. But those treated with London purple showed absolutely no benefit from the application, neither upon the foliage nor upon the fruit. The poison contained nearly seventy-five per cent. of the normal arsenite of calcium, and had been used with success against the codlin-moth in previous years.

The value of former applications of arsenites.—No treatments were made this year that were connected with the destruction of the codlin-moth. During the past two years the orchard had been so thoroughly sprayed with arsenites that it was supposed these applications might have had considerable influence in the extermination of the pest. There is no large apple orchard near the one treated. And this comparative isolation, it was hoped, would not be without its influence. But as the season advanced the consequences of this neglect became more apparent. Not only did the codlin-moth flourish, but also nearly every insect that could in any way disfigure an apple. The curculio was very prevalent, and assisted in the disfigurement of nearly every apple in the orchard. The light crop appeared to compel the insects to concentrate their efforts upon the few apples that were borne, and rarely has a crop of apples shown more clearly the extent to which insects alone can ruin fruit. The average amount of injury obtained from several trees of different varieties, treated and untreated, showed that 76 per cent. of the fruit had been attacked by the codlin-moth; the lowest figure obtained was 70, from a tree thoroughly sprayed with the Bordeaux mixture, and the highest 80, produced by an unsprayed tree. If other insect injuries had been considered, the per cent. would undoubtedly have been nearly 100.

Doubt is sometimes expressed as to the comparative seriousness of the apple-scab and the codlin-moth. It is probable that if the insects had been controlled in the orchard instead of the fungi, the injury done would have been less. And this leads us to the question of the comparative value of all applications. In apple orchards I am convinced that Paris green is the most valuable material that can be used as it is our safest insecticide and possesses also strong fungicidal properties. When to this poison is added properly prepared Bordeaux mixture, the apples borne by the trees should be gathered in almost perfect condition.

Spraying as affecting the bearing of orchards.—The apple-scab fungus has been held responsible for many if not all of the failures of the New York apple orchards to bear during recent years. It was supposed to destroy the young fruit after the blossoms fell, or the blossoms themselves were so injured by the fungus that the fruit did not set. There is undoubtedly much foundation for this theory. Mr. L. T. Yeomans, of Walworth, N. Y., showed me a row of Baldwin apple trees which had failed to produce any fruit during the past year. This row was the outer one of the orchard and it was so close to the next one on the interior that a spray cart could not enter. For this reason it was not treated, and although the remainder of the orchard, which was well sprayed, yielded an enormous crop, this untreated row scarcely bore an apple. The age of the trees, soil, cultivation, and other circumstances were the same in both cases.

This theory will not always explain the non-bearing of apple orchards. The one which has been treated by this station during the past three years has had liberal applications of fungicides and insecticides, with the exception of this year, yet it has not borne a full crop for many years. In 1893 a little more than half a crop was produced, but in 1892 and again in the past season the crop was very small. One of the objects of leaving a new check tree each year as already described, was to determine the extent to which the theory would apply to the McGowen orchard. The treatments have been of some benefit, for the sprayed trees averaged more than twice as much fruit as the unsprayed, but still the yield was very light. Some orchards appear to bear independently of spraying. There is some other cause for the trouble

and I believe it may be improper cultivation or fertilization. Several years will be required to determine this point, but the station has the work now under way, and the results are awaited with considerable interest.

The causes of the rust.—The exact cause of rusty fruit is difficult to find, and as so often happens when the reason for a certain fact is unknown to us, we lay it to the weather. The weather then, considering its nature and the unusual abundance of rust even in unsprayed orchards, may be considered as one of the prime factors which brought about the trouble. Since such an unusual amount of rain fell, this excess of moisture alone may have brought it on.

When we come to sprayed orchards, the severity of the rust increases, probably on account of the chemicals used, and not in consequence of the water applied, as this amount is comparatively small. One of the most severe cases of rust noticed was in the orchard of John W. Spencer, Westfield, N. Y., and these trees had been thoroughly sprayed with the Bordeaux mixture and London purple. In the trees sprayed by this station the rust appeared to increase with the number of treatments, and those which were sprayed with the Bordeaux mixture made with the potassium ferrocyanide test showed the discoloration most strongly. Mr. Spencer used the same test in making his Bordeaux mixture and from all appearances the trouble has been aggravated by the use of the chemical. In the orchard of a prominent fruit grower a pear crop was practically ruined apparently by the early use of the Bordeaux mixture prepared with the aid of this test. Fully seventy-five per cent. of the fruit fell to the ground soon after the application was made, while in a neighboring orchard containing similar varieties, the fruit remained upon the trees.* (See initial illustration, p. 47). The test, therefore, would seem to be unsafe unless more lime is added than appears to be necessary. The

*See also *Garden and Forest* vii. p. 456 for a more complete account of this orchard. The danger of using the Bordeaux mixture made with the ferrocyanide test, was indicated in Bull. 74, p. 382 and 84, p. 12. At about the same time Fairchild's bulletin upon the Bordeaux mixture (Bull. 6, Div. Veg. Path. Dept. Agric.), expressed a doubt as to the advisability of using the ferrocyanide test.

lime will not prevent the trouble, but it may assist in lessening its severity. The formula given on page 52 seems to be as satisfactory as any yet proposed in this country. I have learned, however, that in some parts of Italy a much more dilute mixture is used on grapes, with entire success. The formula recommended in the past by this station is made approximately of a one and eight-tenths per cent. (1.8%) solution of copper sulphate, considering the crystals as weighing 6 pounds and the forty gallons of water 333 pounds. The Italian mixture calls for only seven tenths of one per cent. (.7%) which is equivalent to diluting our mixture to about 104 gallons. Applications made with such a fungicide may not encourage rust, but it might not be equally efficient against the apple-scab. The Italian growers also confess to the necessity of making a greater number of applications when such dilute mixtures are used.

The experiments of Sostegni, some of which have already been referred to in a former bulletin,* have a direct bearing upon this subject. In a later article† he emphasizes the value of having a certain amount of dissolved copper present in the Bordeaux mixture. The chloride of ammonia is added to increase the amount of copper in solution. The solvent action of carbonic acid as found in rain water and dew is also mentioned. The dew found upon grape foliage which had been sprayed was very carefully absorbed by blotting paper and then analyzed for copper. It was found that when ordinary Bordeaux mixture had been applied, in four cases out of five no copper was found in these tests. When the mixture had been prepared with a small amount of lime some copper was found in every case. But the addition of the chloride of ammonia caused a large increase in the quantity of copper held in solution.

In a later paper‡, the same writer gives an account of other experiments from which he draws the following conclusions:

1. The principal cause of the solution of the copper is the carbonic acid dissolved in the water which bathes the leaves upon

*Cornell Agric. Exp. Sta. Bull. 48, p. 291.

†Sostegni, *L'Agricoltura Meridionale*, 1891, No. 17, pp. 261-263.

‡Sostegni. *Giornale di Viticoltura, Enologia, ed Agraria*, 1893, Nos. 12 and 13.

which the Bordeaux mixture has been placed. This explains why the dew that has absorbed this gas acts with great energy as a solvent of the copper compounds.

2. When the leaves treated with the Bordeaux mixture remain for some time in contact with moist air a large part of the copper compounds become gradually soluble. On this account rains may carry away large quantities of the dissolved metal; and it follows that very frequent rains, although of short duration, dissolve and waste more of the fungicide than do more severe rains which follow each other at longer intervals.

3. A great excess of lime in the Bordeaux mixture diminishes the amount of copper held in solution in the clear liquid. When such a mixture is applied to foliage the copper is less widely distributed, and can only be found in these places in which solid particles of the mixture have lodged. The lime retards the solvent action of the carbonic acid gas, since before the latter can act upon the copper compounds the lime must be changed from the hydrate into the carbonate. This may be of advantage during seasons of frequent showers for in such cases less of the copper would be washed from the leaves and lost.

After our experience of 1894 it would appear to be very advisable that an excess of lime be used in making the Bordeaux mixture. But this excess is not put in for the purpose of lessening the waste of dissolved copper, but that foliage and fruit may not be injured by its presence. The conditions, of dry climate, existing in Italy are evidently very different from those found in America, for here dissolved copper is injurious while there it is desired.

THE WORK DONE ELSEWHERE. (pp. 64 to 68.)

By station workers.—The results obtained by Munson* indicate that a combination of the Bordeaux mixture and of Paris green was more effective in preventing apple-scab than was either the Bordeaux mixture used alone, or eau céleste. The result shows that Paris green possesses fungicidal properties, but in this case they are not so strongly marked as has been reported from other stations.

* Maine Agric. Exp. Sta. Bull. 8, Second Series.

Stinson* has found that when apple trees are thoroughly sprayed the total number of windfalls is considerably reduced. The greater part of those from the check tree fell early in the season, while from the sprayed trees they fell mostly when large enough to use. At the time of harvesting, the sprayed trees yielded nearly twice as much fruit as that obtained from the unsprayed trees. The season's work (1893) goes to show that three or four treatments are sufficient to control apple-scab, and it was also noticed that trees which were "sprayed but twice gave about the same per cent. free from scab as those sprayed three times, but the apples were not so large as those sprayed three times."

By growers.—T. H. Walker, Ripley, sprayed R. I. Greening, Baldwin, Twenty-ounce, N. Spy, and a seedling variety, with Paris green and the Bordeaux mixture. The apples were more wormy than was expected, the trees showing from fifty to ninety per cent. of affected fruit. This was undoubtedly very largely due to the fact that the first application of Paris green was not made until May 23, twelve days after the blossoms fell from the trees. A second application of Paris green was made June 6. The falling of the apple blossoms is the signal for the use of arsenites in the destruction of the codlin-moth.

The orchard was sprayed four times with fungicides; the first application was with the copper sulphate solution; the following ones were with the Bordeaux mixture. They were made on the following dates: April 9, April 21, May 2, June 6. The fruit was practically free from scab. The seedling variety had never borne perfect fruit before having been sprayed, but this year the tree was loaded with good fruit free from scab.

Rust was found upon most of the varieties to a considerable extent, and there appears to be no doubt of the injurious action of the Bordeaux mixture in these cases.

Mr. Tenant, of Ripley, sprayed an orchard three times, using only the Bordeaux mixture and Paris green. The former was used alone for the single application made before the blossoms appeared, but the two were applied together as soon as the blos-

* Arkansas Agric. Exp. Sta. Bull. 26.

soms fell, and again about ten days later. From one to two gallons of the mixture were used per tree. In spite of the use of this small amount of liquid, the crop harvested was very fair and the owner is enthusiastic regarding the value of the treatment. The varieties grown are mostly Baldwins, Roxbury Russet and King. Rust was found throughout the orchard but it was not so serious as in that of Mr. Walker.

John W. Spencer, Westfield, sprayed his apple trees very thoroughly the past season, making all the applications generally recommended. The crop, however, showed that careful work added to even the best intentions will not always produce perfection. Mr. Spencer's apples suffered severely from rust, and they were exceedingly wormy, so much so that they could not have been much worse if no application had been made. The reason for this trouble was discovered, but too late to remedy it. London purple had been used in place of Paris green, and it was so deficient in arsenic that about a pound to forty gallons was required to destroy potato beetles. It had been used upon the apple trees at the rate of one pound to nearly two hundred and fifty gallons of water, so of course its action was very slight.

The Bordeaux mixture was made with the use of the ferrocyanide of potassium test. This undoubtedly had much to do with increasing the amount of rust upon the fruit, for the applications were thoroughly and frequently made.

Chas. Colburn, Ripley, sprayed his apple trees once, using Paris green and the Bordeaux mixture. Trees which in former years produced cracked fruit that dropped prematurely to the ground, this year produced fruit that remained upon the trees and matured in much better condition. Only about one and a half gallons of the mixture were used per tree. The applications will be made again in 1895.

H. A. Blowers, Westfield, sprayed his trees with London purple as soon as the blossoms fell to the ground, and repeated the application about three weeks later. No marked difference could be seen between the trees which were sprayed and those which were not treated, but another trial will be made during the coming year.

E. W. Skinner, Portland, sprayed his orchard about the middle of June and again ten days later, using the Bordeaux mixture and

Paris green. Although there was an apparent benefit derived from the treatments, the fruit being about one-third larger, better results might have been obtained if earlier applications had been made. The orchard will be more thoroughly treated next year as the work appears to pay.

F. W. Howard, Fredonia, says he made the first application to his orchard about five days after the falling of the blossoms, using the Bordeaux mixture and Paris green. This was repeated in about ten days. In the fall the apples were of poor quality, the treatments having done apparently no good. The cause of this failure can scarcely be explained unless it is that the fungicide was not applied sufficiently early.

Judge Barker, Fredonia, sprayed Baldwin, Greening, and Spitzenburgh trees with Paris green as soon as the blossoms fell, and in about a week the trees were again sprayed, this time with the Bordeaux mixture as well as with the Paris green. A third treatment was also given the trees, only the Bordeaux being used. The apples gathered in the fall were exceptionally fine. The trees were loaded and the fruit was nearly perfect. This crop was undoubtedly the finest it was my pleasure to see last fall.

The orchard of Hon. S. F. Nixon was treated for the apple-scab and for the codlin-moth. Work was begun late in the season, the first application being made May 24, the second May 31. The Bordeaux mixture and London purple were used in combination for each treatment. The Bordeaux was made with the ferrocyanide of potassium test, and the arsenite was the same as that used by Mr. Spencer, already mentioned on the preceding page. In spite of the late beginning some good was done. The number of first class apples upon the Baldwin trees was as follows: unsprayed 2.7 per cent., sprayed 7 per cent.; upon the R. I. Greening, unsprayed .034 per cent., sprayed 3.8 per cent. The second class fruit on the sprayed trees was also decidedly superior to the same grade of the unsprayed. The gain is small, and goes to emphasize early application and the use of good material.

H. B. Clothier, Forestville, sprayed an orchard in which several varieties were growing, including trees of Baldwin, N. Spy, Greening, and Roxbury Russet. The orchard was sprayed as follows: First, when the buds were nearly ready to burst; second, when

the blossoms had fallen, using Bordeaux mixture and Paris green : third, ten days later with same combination : fourth, ten days later, repeated the last. The leaves were then somewhat affected with scab, but the apples were nearly perfect. On July 5, the condition of the trees was about as follows, the figures denoting the per cent. free from scab; Baldwin, 90; N. Spy, 95; R. I. Greening, 78; Roxbury Russet, 83. This was a decided improvement as could be seen from a neighboring orchard in which similar varieties are grown. The rust was quite serious, but the gain from the application far overbalanced the loss caused by this defect.

PART II. SPRAYING QUINCES FOR LEAF-SPOT, AND THE CRACKING OF THE FRUIT (pp. 68 to 70).

Quinces in all parts of this state are almost invariably attacked by a fungus (*Entomosporium maculatum*). This causes the formation of small circular brown spots upon the foliage, and if a leaf is attacked in several places, those spots may unite in the formation of considerable areas. Such leaves generally assume a yellowish appearance, and they soon drop from the tree. Many trees are entirely defoliated each year by the fungus, the fruit in some instances still persisting. (See Bulletin 80).

The fungus attacks the fruit as well as the foliage. When this takes place early in the year the affected part is checked in its growth, and in consequence the fruit becomes misshapen, and in some portions corky. It may even split open, and is of course rendered entirely worthless for market. Fortunately, however, this disease does not appear to be very active early in the year. I have rarely seen any serious attack before the first of July, and sometimes it is nearly the first of August before much injury is done. These later attacks cause the fruit to appear spotted with small, nearly black, sunken places which do not materially affect the form of the quince, but which nevertheless disfigure it. The fungus thrives in warm, damp weather, and its appearance and severity are largely dependent upon these conditions.

The treatment of this disease is simple and effective. Some good fungicide, as the Bordeaux mixture or the ammoniacal solution of copper carbonate should be sprayed upon the trees

14.—Angers quince, not sprayed.



early in the summer, the date of the first application depending upon the season. Figure 14 shows an unsprayed Angers quince tree, while Fig. 15 shows one which was treated. This received application of the Bordeaux mixture May 18, June 6, June 28, July 16 and August 2. This number of treatments was unneces-

15.—Angers quince, sprayed.



sary, for other trees which were not sprayed until June 6 showed foliage which was apparently just as healthy. The very wet weather seemed to bring on the disease earlier than usual, but trees which had been sprayed resisted the attacks almost perfectly. The fruit was very fair, and large. That borne by trees which were sprayed later, beginning June 28, was more or less spotted, and showed that the work had not been done early enough. Yet in 1891 some quinces which were not sprayed before July 13 preserved their leaves practically uninjured until very late in the fall. Applications which are made to quinces, as well as to so many other fruits, must be made intelligently and with some regard to the season.

PART III. NOTES ON SPRAYING PLUMS (pp. 70 to 74).

In spraying our plum trees for the black knot, of which a report has recently been published,* notes were taken regarding the action of these applications in checking a fungous disease known as leaf-spot (*Septoria cerasina*), causing an appearance resembling that shown in Fig. 10, and the rotting of the fruit, Fig. 11, also caused by a fungus (*Monilia fructigena*). Several varieties received the application, a list being given below, but one unsprayed tree was left in each plot.

More treatments were made than are required for the control of these diseases, but the dates of all applications are here given: March 8, 13; April 20; May 2, 30; June 28; July 16; August 1. If any plum diseases are susceptible to treatment by the use of fungicides these trees should have been free from them.

The leaf-spot or "shothole" fungus of plums first appears during early summer. It causes the formation upon the foliage of small, dark-brown or purplish spots. Such portions soon fall from the leaf, which then appears to have been riddled with shot. Those which are most seriously affected turn yellow and fall to the ground. In this way trees are very often defoliated.

This disease can easily be controlled by making the following applications:

First. About two weeks after the blossoms have fallen, apply the Bordeaux mixture.

Second. Repeat first in two or four weeks, depending upon the

* Cornell Agric. Exp. Station, Bull. 81.

season. The drier the season the less frequently the treatments need be made.

Third. Repeat the first in two to four weeks after the second, if necessary.

The fungus which causes the rotting of the fruit, also attacks the smaller branches, particularly of plums and peach trees. It may penetrate the fruit and even the blossoms early in the year, but it generally is most serious when the plums are nearly full grown. The fruit turns brown in the affected parts, and this color spreads rapidly throughout the fleshy parts and the rotting of the fruit is soon accomplished. Such fruits may remain upon the trees, often fastened together where they come into contact with each other, and they may still be seen the following spring, where they form centers of distribution of the spores which spread the disease during the warm days of the new year. If not controlled, it is a very serious disease and has caused the entire ruin of many crops of plums and of peaches.

The most important treatments made to control this disease are probably the following :

First. Spray the trees before the buds break with the copper sulphate solution.

Second. When the blossoms have fallen apply the Bordeaux mixture.

Third. When the fruit is about two-thirds grown, repeat the second.

Fourth, if necessary spray with the ammoniacal solution of copper carbonate.*

That part of the following table relating to the fruit-rot has been prepared from notes taken August 25. Notes on the leaf-spot were made October 18, when the effects of the treatments were most visible. The figures represent the degree of perfection of the foliage and of the fruit, so the greater the figure the less is the severity of the disease.

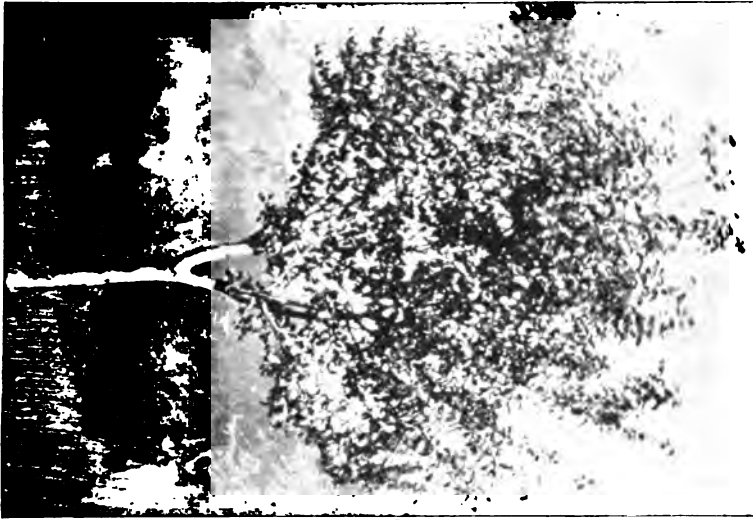
*This fungicide is made by dissolving one ounce of the carbonate of copper in ammonia, and then diluting the solution with nine gallons of water. Before dilution, the blue ammonia liquid should be kept in tightly corked bottles. It may then be used as required.

Name of variety.	Fruit-rot.		Leaf-spot.	
	Check.	Sprayed.	Check.	Sprayed.
Bavay's Green Gage	70	90	50	95
Bradshaw	—	—	50	80
Coe's Golden	—	—	100	100
Pellenburg.....	—	—	0	100
Gen. Hand	—	—	95	100
German Prune.....	—	—	0	95
Imperial Gage	50	90	90	95
Jefferson.....	85	80	100	100
Lombard.....	70	95	90	100
McLaughlin	—	—	10	95
Niagara.....	0	90	100	100
Quackenbos.....	—	—	75	90
Shipper's Pride.....	90	90	85	90
Smith's Orleans ...	90	90	25	90

It is interesting to note the difference in the degree to which the varieties were affected. The Niagara suffered most from fruit-rot, every plum having been destroyed, for a good crop set early in the season. Varieties which are followed by dashes produced no fruit. Imperial Gage lost about one-half of the crop from this disease, while Bavay's Green Gage and Lombard lost about thirty per cent. In the other varieties the loss on the check trees was less severe. No variety of the sprayed trees lost more than twenty per cent. by rot, and this amount occurred only in the case of the Jefferson, it being five per cent. less than the check. I cannot explain this loss. The loss in the other varieties was only five or ten per cent.

The foliage showed some difference when the first notes were taken but not so much as later in the season. Figure 16 represents a tree which was sprayed, while Fig. 17 represents another of the same variety which received no treatment. The photographs from which the illustrations were made were taken October 18. The entire loss of foliage, even though it occurs but a week or two earlier than under normal conditions, must weaken the tree to a certain extent, and the earlier this loss takes place the more will the tree be injured. There is nearly as much difference in the extent to which the several varieties of plum foliage are attacked by leaf-

16.—German prune, sprayed.



spot, as is the case with the fruit and the fungus which causes the rotting.

The foliage also shows much difference in the powers of the varieties to resist disease. Fellenberg and German Prune had lost all their leaves from the check trees, while the sprayed trees

17.—German prune, not sprayed.



still retained their leaves in an almost perfect condition. Bradshaw was also seriously affected. Coe's Golden, Jefferson, and Niagara showed no fungous disease upon either the sprayed or the unsprayed foliage, but all the other varieties were more or less attacked.

The large number of applications which were made this year seemed to have an influence upon the thickness of the foliage. Leaves were taken October 15 from sprayed and unsprayed trees of three varieties of plum, Fellemborg, Bradshaw, and German Prune. Five leaves were selected for each lot, and they were taken from corresponding portions of the trees. In making the sections the material was uniformly cut from near the midrib, in the vicinity of the center of the leaf, so that no error might creep in from this direction. The average of the measurements are as follows:

Fellemborg, sprayed 10.6 micromillimeters; unsprayed 10.4 m.,
a gain of 1.9 per cent.

Bradshaw, sprayed 10.9 micromillimeters; unsprayed 10.6 m.,
a gain of 2.8 per cent.

German prune, sprayed 12.9 micromillimeters; unsprayed 11.7 m.,
a gain of 10.2 per cent.

The differences between the sprayed and the unsprayed foliage, although very slight in cases of the first two varieties, are nevertheless uniformly in favor of the sprayed foliage. This is most plainly shown in the leaves of the German prune. It would appear that the Bordeaux mixture has an influence upon the foliage causing it to become thicker, or that the increased vigor of the tree brings about this result. It has often been said by careful observers that apple foliage is benefited by such applications, ignoring entirely the protective action of the Bordeaux mixture against fungi. The particular cells of the plum leaves which were enlarged could not be determined with certainty, but the palisade cells appeared to be longer in the sprayed leaves.

SUMMARY.

1. Hand pumps have proved the most satisfactory machine for spraying apple orchards. Page. 48.
2. Power sprayers have proved unsatisfactory because they do

not throw enough liquid, and they do not throw the spray far enough. Page 48.

3. Power sprayers are excellent machines to use in spraying grapes and low growing plants. Page 50.

4. Rusty fruit was found upon Baldwin, King, Red Astrachan and Fallawater trees, but none upon Fall Pippin. Page 53.

5. Four applications of the Bordeaux mixture made to King trees protected the fruit well from the scab, but it is probable that three would have been sufficient. Page 55.

6. The two most important applications made for combatting the apple-scab consist of the one which is made just before the blossoms open, and the one made as soon as they fall. Page 56.

7. If a third treatment is advisable it should be made about two weeks after the falling of the blossoms. Page 57.

8. The use of three gallons of Bordeaux mixture upon bearing trees from twenty-five to thirty years of age, seems to be advisable; for a part of the beneficial action of this fungicide may be the lessening of insect, especially curculio, injuries. Page 58.

9. Former applications of the Bordeaux mixture upon the trees of this orchard appeared to possess little value in perfecting the crop this year, but all circumstances were not favorable to an accurate experiment regarding this point. Page 59.

10. The early use of the copper sulphate solution may be of value if orchards are uniformly and thoroughly sprayed with it. In our experimental orchard, with unsprayed trees as probable sources of infection, the value of such treatments has not been very marked. Page 59.

11. London purple possesses no fungicidal properties. Page 60.

12. Former applications of arsenites appear to have exerted no influence in suppressing insect ravages during the past season. Page 60.

13. If only one substance is applied to apple orchards, it should generally be Paris green. Page 61.

14. Spraying orchards in some cases increases the yield of fruit from practically nothing to a full crop, but in other cases the operation is followed by nearly negative results in this direction. Page 61.

15. It is doubtless true that much of the failure of apple or-

chards to bear is due to the want of proper fertilization and cultivation. Page 62.

16. The true cause of the formation of rusty apples is obscure, but the character of the season appears to influence the severity of the attack. Page 63.

17. The Bordeaux mixture has a tendency to produce rusty fruit even when prepared according to the formula given on page 52.

18. The ferrocyanide of potassium test used in the manufacture of the Bordeaux mixture is not so satisfactory as was at first thought, for the mixture when so prepared may be injurious to the fruit. Page 62.

19. Munson has shown that Paris green possesses fungicidal properties. Page 64.

20. Stinson has shown that fruit sprayed three times was larger than that sprayed twice, although the per cent. of scab on both lots was the same. Page 65.

21. Paris green must be applied immediately after the blossoms fall in order to be most effective against the codlin-moth. Page 65.

22. Rust was very prevalent in Chautauqua county the past season, but apple growers, on the whole, are well satisfied with results obtained from spraying. Pages 65-68.

23. London purple is an unreliable insecticide in some cases. Page 66.

24. The failures which have occurred may be due largely to the lateness or the hastiness of applications. Pages 66-67.

25. The leaf-spot and the cracking of quinces may be controlled by the proper use of Bordeaux mixture. Page 68.

26. Applications for the control of this disease need not be made so early as in the case of the apple-scab fungus. Page 68.

27. The shot-hole fungus attacking plum and cherry foliage can be controlled by the use of Bordeaux mixture as described on page 70.

28. The fruit-rot of plums and peaches can be checked by the use of the fungicides mentioned on page 71.

29. Some varieties of plums are more subject to the attacks of fungi than others. Page 72.

30. Spraying plum foliage with the Bordeaux mixture thickens the leaves, but further measurements must be made to establish a rule. Page 74.

E. G. LODEMAN.



[1849

630.679

N7

682k

Bulletin 87.

April, 1895.

Cornell University Agricultural Experiment Station.

HORTICULTURAL DIVISION.

The Dwarf Lima Beans.



By L. H. BAILEY.

**PUBLISHED BY THE UNIVERSITY,
ITHACA, N. Y.
1895.**

ORGANIZATION.

BOARD OF CONTROL:

THE TRUSTEES OF THE UNIVERSITY.

STATION COUNCIL.

President, JACOB GOULD SCHURMAN.

Hon. A. D. WHITE,	-	-	-	Trustee of the University.
Professor I. P. ROBERTS,	-	-	-	President State Agricultural Society.
Professor I. P. ROBERTS,	-	-	-	Agriculture.
Professor G. C. CALDWELL,	-	-	-	Chemistry.
Professor JAMES LAW,	-	-	-	Veterinary Science.
Professor A. N. PRENTISS,	-	-	-	Botany.
Professor J. H. COMSTOCK,	-	-	-	Entomology.
Professor L. H. BAILEY,	-	-	-	Horticulture.
Professor H. H. WING,	-	-	-	Dairy Husbandry.
Professor G. F. ATKINSON,	-	-	-	Cryptogamic Botany.

OFFICERS OF THE STATION.

I. P. ROBERTS,	-	-	-	Director.
E. L. WILLIAMS,	-	-	-	Treasurer.
H. W. SMITH,	-	-	-	Clerk.

ASSISTANTS.

M. V. SLINGERLAND,	-	-	-	Entomology.
GEO. C. WATSON,	-	-	-	Agriculture.
G. W. CAVANAUGH,	-	-	-	Chemistry.
E. G. LODEMAN,	-	-	-	Horticulture.
MICHAEL BARKER,	-	-	-	Horticulture.

Office of the Director, 20 Morrill Hall.

Those desiring this Bulletin sent to friends will please send us the names of the parties.

BULLETINS OF 1895.

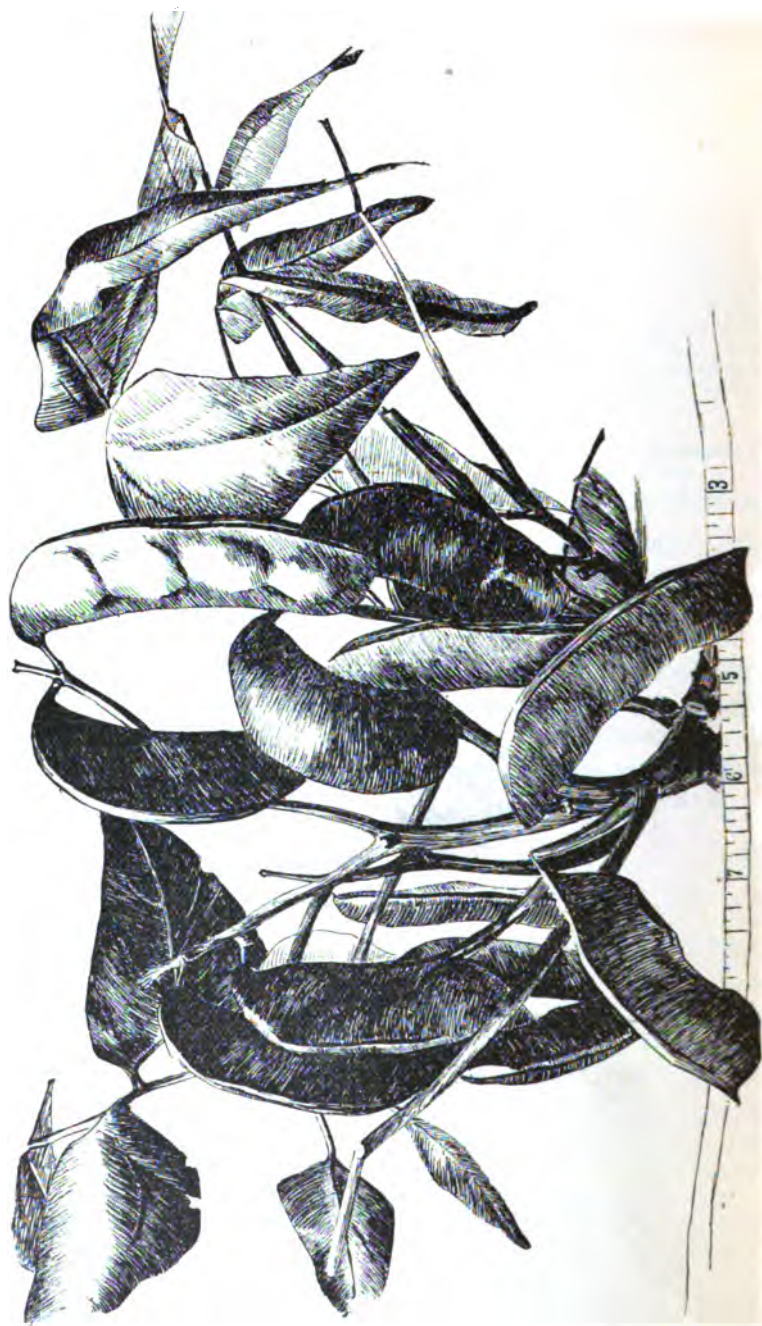
84. The Recent Apple Failures in western New York.
85. Whey Butter.
86. Spraying of Orchards.
87. The Dwarf Lima Beans.

CORNELL UNIVERSITY, ITHACA, N. Y., }
April 1, 1895. }

THE HONORABLE COMMISSIONER OF AGRICULTURE, ALBANY.

Sir: One of the most novel and interesting recent features of vegetable gardening is the sudden appearing of a number of dwarf or bush beans of the Lima bean type. The ordinary or pole Limas are an uncertain crop in many parts of western New York, and people are looking to these dwarf forms for varieties which are adapted to our seasons and which do not require the annoyance and expense of poling. We have made a careful study of them, and submit the account for publication under Section 87, Chapter 675, of the Laws of 1894.

L. H. BAILEY.



17. Thorhurn or Kumerle Dwarf Lima. (Page 96.)

THE DWARF LIMA BEANS.



BEANS of the dwarf Lima type have attracted much attention during the past few years, but there appears to be considerable confusion as to their merits and little positive knowledge of their botanical features. The writer began the study of this class of beans in 1889, when Kumerle and Henderson dwarf Limas were introduced, and the investigation has been continued until the present time. It was not until last year, however, that the whole subject was carefully gone over with a view of publication, in response to many inquiries for definite information respecting this interesting type of garden vegetables. Some unexpected results have followed this study, particularly in respect to the botanical affinities and the histories of the varieties.

In the first place, it should be said that the dwarf Lima beans constitute a new type of garden vegetables. They have all appeared in public within the last decade, and they are apparently nearly unknown in other countries, except as introductions from North America. Seedsmen and horticulturists often remark that when any very decided variety of plant is introduced, other varieties of the same general type are likely to at once appear. Gardeners will recall, amongst many other instances, the case of the large-leaf tomatoes, the Mikado, Turner Hybrid and Potato Leaf all appearing nearly simultaneously. This curious phenomenon has been forcibly stated by one of our leading seed experts,* as follows :

" Plants have inherent tendencies to variation which are developed and appear only after years of cultivation. Seedsmen receive every year scores of new potatoes raised from seed, and it is astonishing how much resemblance there is in the seedlings of any

* W. W. Tracy, of D. M. Ferry & Co., in Proc. Sixth Meeting Soc. Prom. Agr. Sci. 47 (1885).

period of about three years. Thus, a few years ago we had the St. Patrick, Burbank and White Star, which, although distinct varieties and raised under very different circumstances, are certainly very similar to each other. Later we have appearing the Mayflower, Garfield, and many other similar sorts. And the appearance of any distinct variety is sure to be followed by others, which although raised from entirely different stock, are very similar to the first. The Favorite tomato is followed by the Optimus, Beauty, and a score or more of unnamed varieties raised in different localities and from different stock, but of comparatively little commercial value because so similar to the named sorts; but if any one of them had appeared a year or two earlier, it would have been regarded as of the greatest value. It is claimed that the hard-spelled Champion, or Kolb's Gem watermelon originated in Georgia in 1882 from a cross between Scaly Bark and Cuban Queen. It is quite distinct from any observed sport or cross appearing before that date, but I know of two unnamed sorts originating in 1882—one in Illinois and the other in Florida—from different parentage, but practically identical with the Gem. The Minimum and American Wonder peas originated about the same time—the one in England, the other in America—and were a new type of evident value and importance, which, had it appeared among the thousands of new sorts raised before that time, would have been extensively propagated and sold: but these two named sorts are only two of many peas of that type which appeared at that time."

There has been considerable speculation as to the cause of this singular synchronism, or the nearly simultaneous appearing of similar types. It was long a source of perplexity to me, and it is not yet wholly explicable, although these dwarf Lima beans, which we are about to study, offer some explanation of the question. These beans afford a remarkable instance of synchronistic variation. Henderson and Kumerle dwarf Limas were introduced in 1889, Burpee in 1890*, Jackson Wonder in 1891, and Barteldes in 1892 or 1893. The variety which is now called the Hen-

* The statement in *Annals of Horticulture* for 1899 (p. 97) that Burpee Bush Bean was introduced in 1889, is an error. The dwarf Lima which Burpee offered that year was the Henderson.

derson was picked up twenty or more years ago by a negro, who found it growing along a roadside in Virginia. It was afterwards grown in various gardens, and about 1885 it fell into the hands of a seedsman in Richmond. Henderson purchased the stock of it in 1887, grew it in 1888, and offered it to the general public in 1889. The introduction of Henderson's bean attracted the attention of Asa Palmer, of Kennett Square, Pennsylvania, who had also been growing a dwarf Lima. He called upon Burpee, the well-known seedsman of Philadelphia, described his variety, and left four beans for trial. These were planted in the test grounds and were found to be valuable. Mr. Palmer's entire stock was then purchased,—comprising over an acre, which had been carefully inspected during the season—and Burpee Bush Lima was presented to the public in the spring of 1890. Now, Mr. Palmer's dwarf Lima originated in 1883, whilst Henderson's originated at least ten years earlier; and Mr. Palmer made his own variety public because he was attracted by Henderson's advertisement. In other words, the simultaneousness of these two varieties was only an apparent one. This is certainly true of many apparently simultaneous varieties. They have originated at widely different times and in different ways, and have been cultivated year after year, perhaps, in obscure places. When someone introduces a strange type, attention is directed to all similar varieties, and they are called into notice, in the same way that an unusual event in some locality is often followed by the recital of other similar events.

Yet it is true that, speaking broadly, there is a general tendency in any species, and amongst closely related species, to vary in similar directions. The angular or cornered tomatoes of a generation ago are rapidly passing into the large round apple-shaped tomatoes, particularly in North America, where this evolution has progressed farther than elsewhere in the world. All varieties of potatoes are progressing towards seedlessness. There are reasons for these general onward movements of plants, which cannot be explained here. All that need be said in explanation of this tendency is the fact that the beans tend to vary into bush or non-twining forms. We shall discover presently that these dwarf Lima beans are offshoots of two or three distinct species. We

know that the original forms of these species were climbing plants. Now, this known tendency to the production of dwarf forms in these three species or types of so-called Lima beans, affords an excellent illustration of how the common field and garden beans must have originated. The common bean, both in its pole and bush form, is wholly unknown in a wild state. Even its native country is undetermined, although there is the strongest circumstantial evidence that the species is American. Linnæus, over a hundred years ago, described two species of the garden kidney bean, *Phaseolus* (pronounced Fasé-o-lus) *vulgaris*, the pole bean, and *Phaseolus nanus*, the bush bean. It is now generally agreed that these two forms are horticultural modifications of one original type. But which was the original form, the twiner or the bush form? If all the so-called bush Limas are known to have come from twining plants, there is, thereby, the strongest reason for supposing that the common bush beans originated from the twiners, a conclusion which is also supported by much other evidence.

The reader is now anxious to know just how these dwarf Lima beans originated. They appeared in the same way that nearly all new varieties of plants originate: they were found growing amongst plants of common and well known varieties. A single plant, a "sport," was first observed in some cases, and in others several original plants were discovered. The Kumerle or Thorburn Dwarf Lima originated from occasional dwarf forms of the Challenger Pole Lima which J. W. Kumerle, of Newark, New Jersey, found growing in his field. The Henderson, as we have seen, was a chance dwarf picked up in Virginia. The Burpee came from a single plant of the Large White Lima. Mr. Palmer, with whom it originated, had his entire crop of Limas destroyed by cut-worms in 1883. He went over his field to remove the poles before fitting the land for other uses, but he found one little plant, about ten inches high, which had been cut off about an inch above the ground but which had re-rooted. It bore three pods, each containing one seed. These three seeds were planted in 1884, and two of the plants were dwarf, like the parent. By discarding all plants which had a tendency to climb, in succeeding crops, the Burpee Bush Lima, as we now have it, was developed.

The singular Barteldes Bush Lima came from Colorado and is a similar dwarf sport of the old White Spanish or Dutch Runner bean. Barteldes received about a peck of the seed and introduced it sparingly. It attracted very little attention, and as the following season was dry, Barteldes himself failed to get a crop, and the variety was lost to the trade. Just why these bush forms should appear in these instances, we must ask mother nature, and it is possible that she will never be persuaded to give an explicit reply. We hear much about the scientific origination of varieties, but as a matter of fact, the science of the horticulturist is exercised much more in determining when a given form is valuable and in the subsequent breeding or selection of it, than in any power which he possesses over the original genesis of novel types. Certainly, with the dwarf Lima beans, the horticulturist owes less thanks to science than to good luck and cut-worms.

* * *

Before proceeding to an account of the actual merits of these dwarf Lima beans, I must still further bewilder my reader with a discussion of the botany of them. So far as we can determine from any literature yet written, these beans are simply dwarf forms of various Limas. But this is not sufficiently explicit. There are three well marked types or groups of Limas in cultivation in this country, two of which have been considered by many botanists to represent distinct species. Linnæus, nearly a hundred and fifty years ago, described two species of beans, which modern botanists consider to be the parents of the so-called Lima beans of gardens. Now, the dwarf Lima beans have sprung from each of the three different types of pole Limas, and one of them is a semi-perennial plant and is an offshoot of the same species which gives us the Scarlet Runner, Painted Lady and White Dutch Runner. The botanical types from which these so-called dwarf Limas have sprung may be arranged as follows :

- I. *Phaseolus lunatus*, Linn. (Sp. Pl. 724, 1753). Carolina, Sieva, Sewee, Saba, Sivy, Civet, Sky, West Indian and Butter Beans. Bushel Bean of early American writers. *Phaseolus bipunctatus*, Jacquin, Hort. Vind. i. p. 44, t. 100 (1770) is com-

monly referred to Linnæus' *P. lunatus*, and it is probably an outlying form of it, but it is not in cultivation in this country, so far as I know. It differs from our Sievas by its long leaves, different pod, and conspicuous hairiness.

Dwarfs.—Jackson (Jackson Wonder); Henderson; Northrup, Braslan and Goodwin Dwarf Lima; Dwarf Carolina.

I A. *Phaseolus lunatus* var. *macrocarpus*, Bentham (Flora Brazil. xv. i. 181, 1862). *P. inamænus*, Linn. Sp. Pl. 724; Jacq. Hort. Vind. i. p. 27, t. 66. Other specific names which seem to belong here are *P. Limensis*, *P. saccharatus*, *P. fecundus*, *P. latisiliquus*, Macfayden, Fl. Jamaica (1837); *P. puberulus*, HBK. Nov. Gen. vi. 451; *P. Xuarezii*, Zucc. in D C. Prodr. ii. 393.

This is the Lima bean of American horticultural literature. We may distinguish two leading types:

1. Potato Limas, characterized by tumid or nearly spherical beans.

Dwarf.—Thorburn, Kumerle or Dreer.

2. Flat or large limas, with very large and flat veiny seeds, a tall growth and late maturity.

Dwarf.—Burpee.

II. *Phaseolus multiflorus*, Willd. (Sp. Pl. iii. 1030). *P. coccineus*, Lam. Encyc. iii. 70, not of Linnæus. Scarlet Runner, Painted Lady, White Dutch Runuer, and Spanish beans.

Dwarf.—Barteldes.

The above classification accounts for all the so-called dwarf Limas, seven in number, with which I have met. It will aid us to understand the subject if we briefly stretch the history and distinguishing marks of these various types.

I. The Sieva or Carolina bean is a small and slender grower, as compared with the large Limas, early and hardy, truly annual, with thin, short and broad (ovate-pointed) leaflets, numerous, small papery pods which are much curved on the back and provided with a long upward point or tip and which split open and twist when ripe, discharging the seeds; beans small and flat, white, brown or variously marked with red. The beans are shown at Nos. 1, 2 and 3 in Fig. 24, and the foliage and pods on the cover illustration and in Figs. 25 and 26. This type is always

distinguishable from the large Limas with the greatest ease, and is really as distinct from that type as *Phaseolus multiflorus* is. I am inclined to believe that it will eventually be discovered to have had a different specific origin from the Limas. Always smaller than the true Limas, it also has a well known tendency to vary into small or bush forms, as in the Dwarf Carolina, a half-dwarf which has been well known for many years, and this tendency is apparently much more strongly developed than in the Limas.

Linnaeus believed that this bean came from Bengal, but it is now understood to be South American, although it is not certainly known in a wild state. It was early known in North America. Lawson, in his voyage to Carolina in 1700-8, mentions Bushel Beans as a spontaneous kind. Gray and Trumbull* guess that this may have been a form of *Phaseolus multiflorus*, or Scarlet Runner, but this is very improbable. M' Mahon mentions it in 1806 in his "American Gardener's Calendar": "What is commonly called the Carolina bean is only a small and early variety of Lima bean." Deane also speaks of it in New England in 1797 as "being cultivated in this climate of late to advantage,"† but, he does not mention the Lima bean. Gardiner and Hepburn, in the "American Gardener" 1804, do not mention it, although the Lima is recorded. The early cultivation of the plant amongst the Indians and settlers of Carolina, no doubt gave it the name of Carolina bean. The origin of the various other names which it has received is not so easily determined, but since the plant is evidently of tropical origin and is often known in early writings as the West Indian bean, I suppose that its name Saba comes from the island Saba in the West Indies; and it is not unlikely that Sieva and Sewee are derivations from the same name. The word Civet, which is possibly of European origin, is probably derived from the use of the beans in the dish known as civet stew.‡

**Amer. Journ. Sci.* xxvi. 133.

†*New England Farmer*. 2nd ed. 23.

‡I have made a careful search for the origin of the names of this bean. Professor Massey, of the North Carolina Experiment Station, to whom I addressed an inquiry, writes as follows:

"I am sorry that I am unable to help you in the search for the origin of the name Sieva, or Sewee, as applied to the small-seeded Lima bean. I have

IA. The Lima bean is distinguished from the Sieva by its tall growth, lateness, greater susceptibility to cold, perennial in tropical climates, large thick often ovate-lanceolate leaflets, and fewer thick fleshy straight (or sometimes laterally curved) pods without a prominent point and not readily splitting open at maturity ; seeds much larger, white, red, black or speckled. Dwarf forms of the Lima are shown in Figs. 27, 28 and 29, and in Nos. 4, 5, and 6 of Fig. 24.

Linnaeus thought that this bean came from Africa, but it is now well determined that it is South American. Unmistakable seeds have been taken from Peruvian tombs and the plant has been found wild in Brazil. I do not know the origin of the word Lima, which, according to De Candolle, has been used "since the beginning of the century," but I suppose that it comes from the city Lima in Peru. The name has been commonly employed by writers in America from 1804 to the present time, and it is probably of still earlier origin. The two forms, the round-seeded or potato Lima, and the large flat Lima, were early known and described in Europe, the latter, and evidently the former, as early as Lobel, 1591.

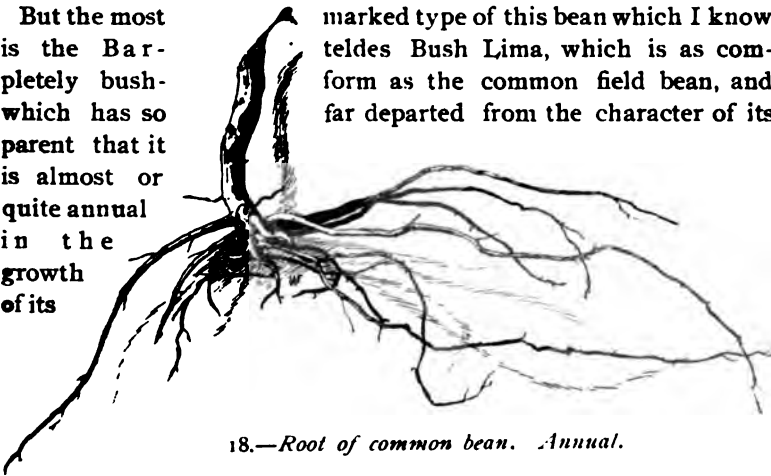
II. The Scarlet Runner and Dutch Runner type of beans (*Phaseolus multiflorus*) is probably native to Mexico, or perhaps of regions to the southward. It is cultivated mostly as an ornamental plant in this country, and yet the young pods and the ripe beans are excellent for the table. There are only two varieties—mentioned above—in common cultivation in this country. It appears to be in greater favor as an esculent amongst the Mexicans. In 1891 a single bean was sent me from Colorado as "Mexican bean." The plant, as we grew it in our forcing-houses, was apparently identical with the White Dutch Runner, except that its tuberous root was larger than any which I had seen else-

often wondered where the name came from and have looked up all I can find on the subject. The only thing that ever seemed like an explanation was that given by an old man in South Carolina, who thought it was originally the 'Seaweed' bean, indicating that the seeds had drifted ashore in seaweed. I can find no foundation for this notion, and simply give it for what it is worth. I know of no local name of any section or district from which it could have been derived. It may possibly be a Cherokee name, for their names very commonly ended with double e, and they always give the accent on this last syllable."

where,—for all these beans are perennials. We were unable to induce the plant to fruit, although the flowers were hand pollinated. A subsequent experience which I had with the western form of this species was in the spring of 1894, when I grew the Melde Perennial and Irvine Hybrid Perennial, which were distributed for trial by the California Experiment Station in 1893 and 1894. It is supposed that the latter is a hybrid between the Lima and Painted Lady beans, but I can find no evidence of hybridity, and I have no hesitation in calling it a straightforward variety of *Phaseolus multiflorus*.

But the most is the Barteldes Bush Lima, which has so parent that it is almost or quite annual in the growth of its

marked type of this bean which I know Barteldes Bush Lima, which is as conform as the common field bean, and far departed from the character of its



18.—Root of common bean. Annual.

root. The illustrations explain this curious evolution towards an annual root. Fig. 18 shows the root of a common bush bean (Sion House). The root lacks wholly any tap-root, and the fibres are hard and woody and die completely when the beans mature. Fig. 19 is a root of one of the most perennial types of Barteldes Bush Lima, and it shows the fleshy tap-rooted character of the root-system. This root remains live and fleshy after the tops are killed by frost, and it would no doubt grow the following spring if not killed by the winter. From the same packet, some seeds of Barteldes Bush Lima produce roots which are almost perfectly fibrous and which gradually die after the top has been cut short by frost, as in Fig. 20. This root is imperfectly annual; and I have no doubt that if attention were given to the matter, a

truly annual bean could be developed from this type in a comparatively short time.

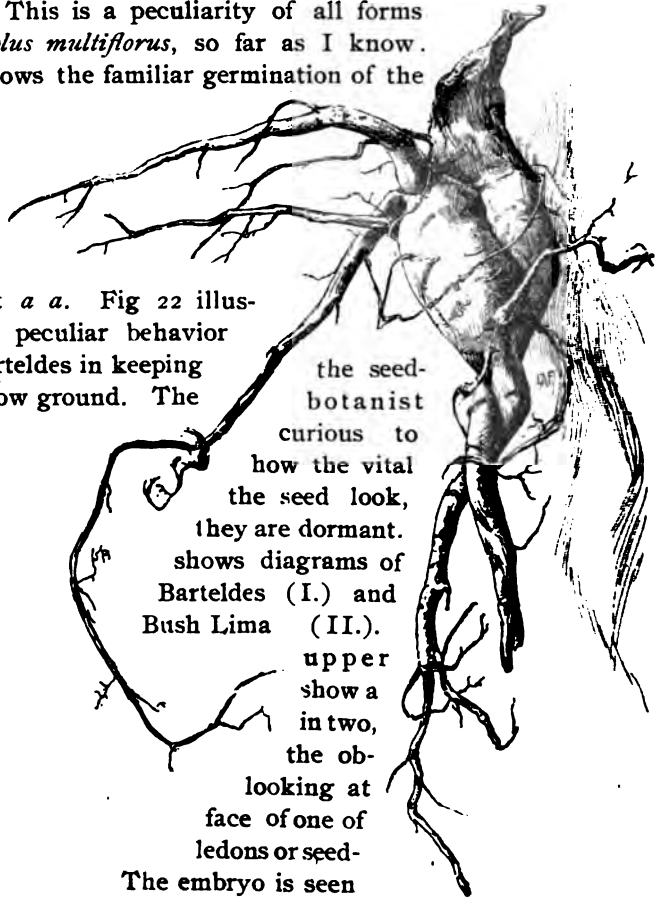
Another peculiarity of this Barteldes bean is that the cotyledons, or halves of the bean, remain below ground when the seed germinates. This is a peculiarity of all forms of *Phaseolus multiflorus*, so far as I know.

Fig. 21 shows the familiar germination of the common bean with the seed-halves appearing above ground at *a a*.

Fig. 22 illustrates the peculiar behavior of the Barteldes in keeping halves below ground. The

will be known parts of when Fig. 23 shows diagrams of a seed of Burpee. The two diagrams show a seed split so that the observer is the inside the cotyledons.

The embryo is seen at the left. At *r* is shown the radicle or root portion, at *e* the stem portion, and at *a* the junction of the two. At the tip of the embryo are the two little bodies which are to become the first true leaves of the plantlet. It will be noticed that the radicle of I.—the Barteldes—is short, whilst the stem portion is long as if



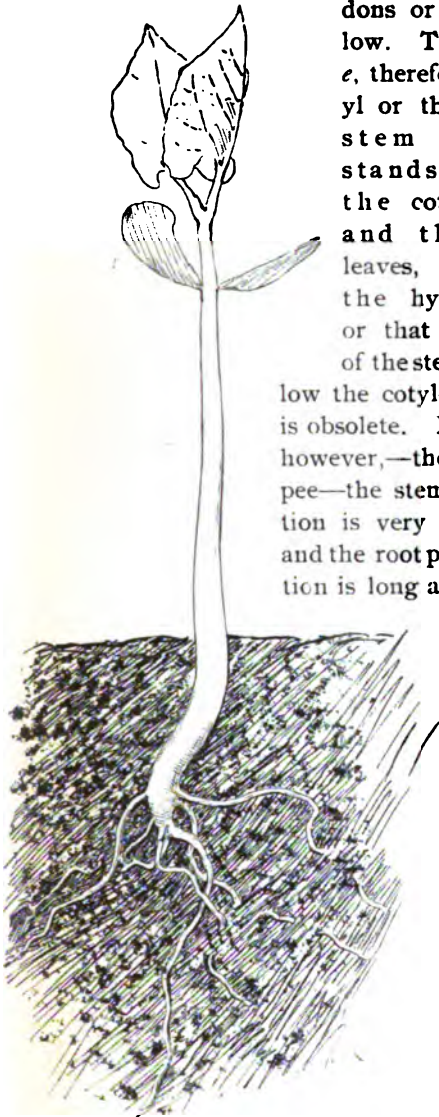
19.—Fleshy or perennating root of Barteldes Bush Lima.

in readiness to elevate the leaves into the air, leaving the cotyledons or seed-halves below.

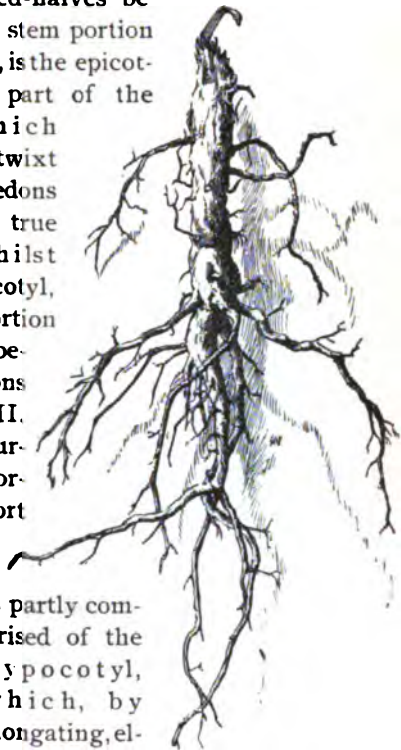
This stem portion *c*, therefore, is the epicotyl or that part of the stem which stands betwixt the cotyledons and the true leaves, whilst the hypocotyl, or that portion of the stem below the cotyledons is obsolete. In II. however,—the Burpee—the stem portion is very short and the root portion is long and

is partly comprised of the hypocotyl, which, by elongating, elevates the seed-halves

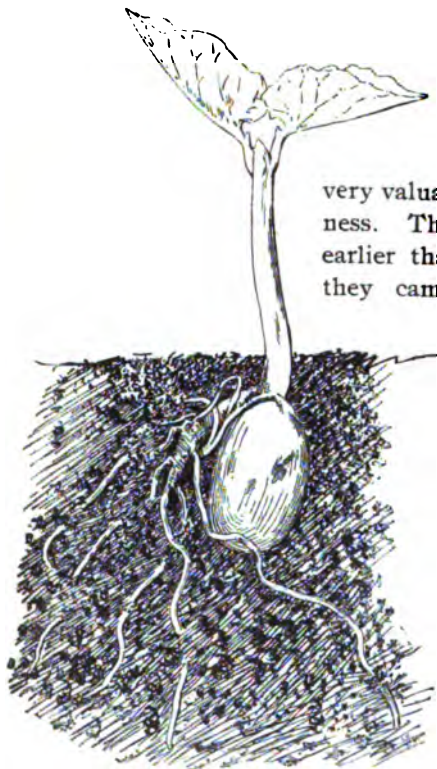
into the air. If, now, the outer covering or skin is removed, and the bean is placed on its back, we see the parts as shown in the lower diagram. Here, again, only one-half of the bean is shown. These views emphasize the long radicle of the Burpee (on the left) and the very short radicle of the Barteldes (on the right).



21.—Germination of the common bush bean.

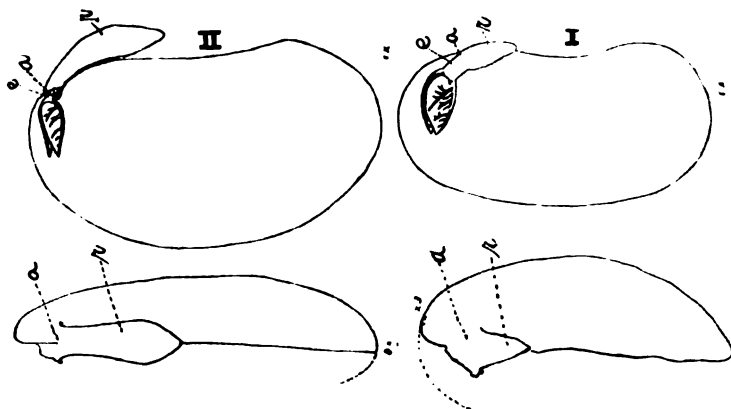


20.—Fibrous plur-annual root of Barteldes Bush Lima.



22.—Germination of Barteldes Bush Lima.

I have finally arrived at the point of saying something about the economic value of these dwarf Lima beans. I am convinced that these beans, as a class, are very valuable. Their great merit is earliness. They are from two weeks to a month earlier than the tall varieties from which they came. Their productiveness has not been reduced in proportion to the reduction in size of the plants, so that I believe that it is possible, in the north, to secure greater total yield per acre from the dwarfs than from the pole varieties, seeing that the plants require less room. They are also much cheaper to grow. They require no poles. In central New York, the tall Lima beans are always a precarious crop, on account of their lateness and the liability of being injured by midsummer droughts at the time when the pods are setting. The earliest var-



23.—Structure of the Lima and Multiflorus beans.

ieties of these dwarf Limas are those which are derived from the Sieva type, as Henderson and Jackson. The following field notes of the varieties indicate our experience with them : *

Henderson Bush Lima (No. 2, Fig. 24 ; Fig. 25).—Very dwarf, with only an occasional plant producing a feeble tendency towards a climbing stem, requiring no more space than field beans ; plant compact, bushy, very productive and continuing long in bearing ; very early ; beans small, flat, clear white ; quality good. A patch planted on the 6th of June last year was bearing well the second week in August, notwithstanding the almost unprecedented drought. An occasional plant produced speckled beans. This seems to be the best variety for earliness, and its great productiveness and habit of long bearing are additional recommendations. The pods also escape the mildew, which is often serious upon the late, thick-podded sorts. Whilst good in quality, it lacks the buttery and rich quality of the true Limas.

Jackson (No. 3, Fig. 24 ; Fig. 26).—This variety, commonly known as Jackson's Wonder, differs from the Henderson in having brown-speckled beans, and in a less dwarf and compact habit, and it is possibly a little later. In productiveness it even excels the Henderson. All of the vines in our plantations have made a diffuse, sprawling growth, and many of them make twining shoots two feet long. On account

* The reader will also find a good account of two or three of the dwarf Limas in 2nd. Rep. Kans. Exp. Sta. 150, with illustrations (1889).



22.—Germination of Bartelde



LAF.

Very bushy
tendency to
long-ovate or
as deltoid at
thick; beans
cellent quali-
rately produc-
ted June 6th
beans the [first
tember. The
8 inches high,
r the potato
; a dwarf type
Large White

25.—Henderson Bush Lima (open
pod nearly natural size).

Bush Lima (No. 5, Fig. 24) is the same,
from Mr. Kumerle's stock.
No. 6, Fig. 24; Figs. 28 and 29).—A true
rf, although somewhat taller and wider



growing than Thorburn (16 to 30 inches high), with little or no tendency to climb; leaflets broadly ovate; pods large and thick; beans as large as pole Limas, very flat and veiny, of the highest quality; season medium to late, beginning to ripen about two or



26.—*Jackson Dwarf Lima.*

three weeks after the Henderson; productive. Upon our grounds this has been the best single variety of dwarf Lima.

With us last year, the Burpee was rather earlier than the Thorburn, although there is little difference in season between these two types. The following notes on the season of the three types of

28.—*Burpee Bush Lima*.

dwarf Limas were made in Massachusetts in 1892 :* " May 25, sowed Henderson, Dreer and Burpee Bush Limas. Picked Henderson August 10; Dreer August 23; Burpee August 24. Summary: Henderson, early, small but very productive; Dreer, medium sized but very fine flavored; Burpee, very large and more productive than Dreer." With us, the Burpee has been more

productive than the Thorburn type, but others have had contrary results. It is probable that there is no constant difference between the two in productiveness.

Barteldes Bush Lima (No. 7, Fig. 24; Figs. 30 and 31).—A small bushy plant of rather weak and sprawling habit, about the size of plants of the field bean; pods 5 or 6 inches long, more or less depressed between the seeds, containing three or four large, oblong and plump white beans which are of good quality. It is

* Alfred G. Clark, *Amer. Gard.* xiv. 110.

very late at Ithaca, maturing only a few of the earliest pods before frost, and is therefore apparently of little account for this latitude. It appears to be unproductive, also.

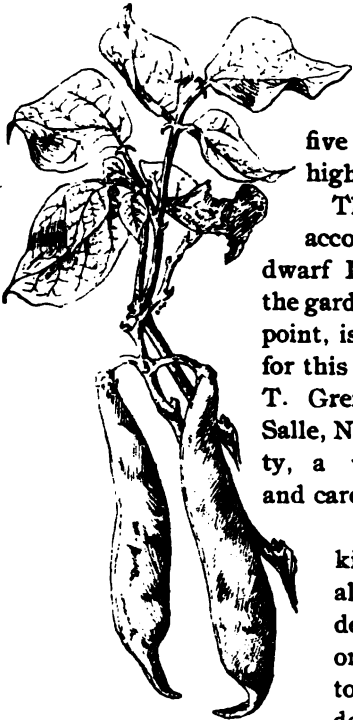
We have endeavored to force the Henderson and Burpee under glass. The Henderson has some promise, although it is doubtful if it will ever pay to force any other bean than the string or snap beans. But we shall try it again. Burpee ran to vine, and was unproductive. Whilst it is

generally a complete dwarf in the field, it runs

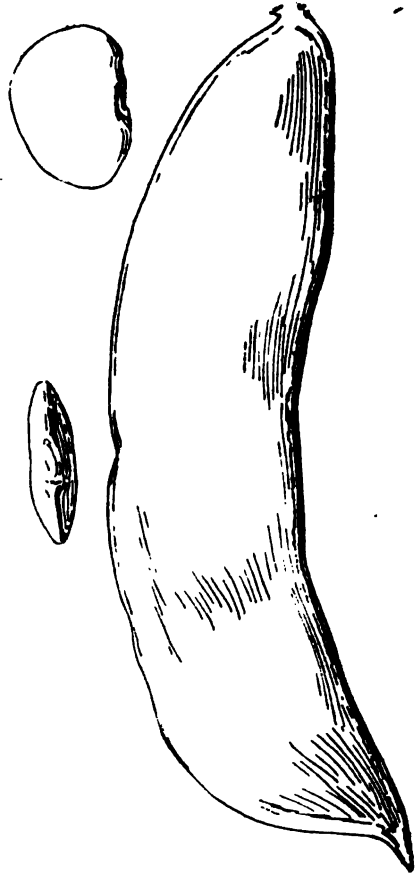
five to seven feet high in the house

The following account of the dwarf Limas, from the gardener's standpoint, is contributed for this occasion by T. Greiner, of La Salle, Niagara County, a well known and careful horticulturist and author :

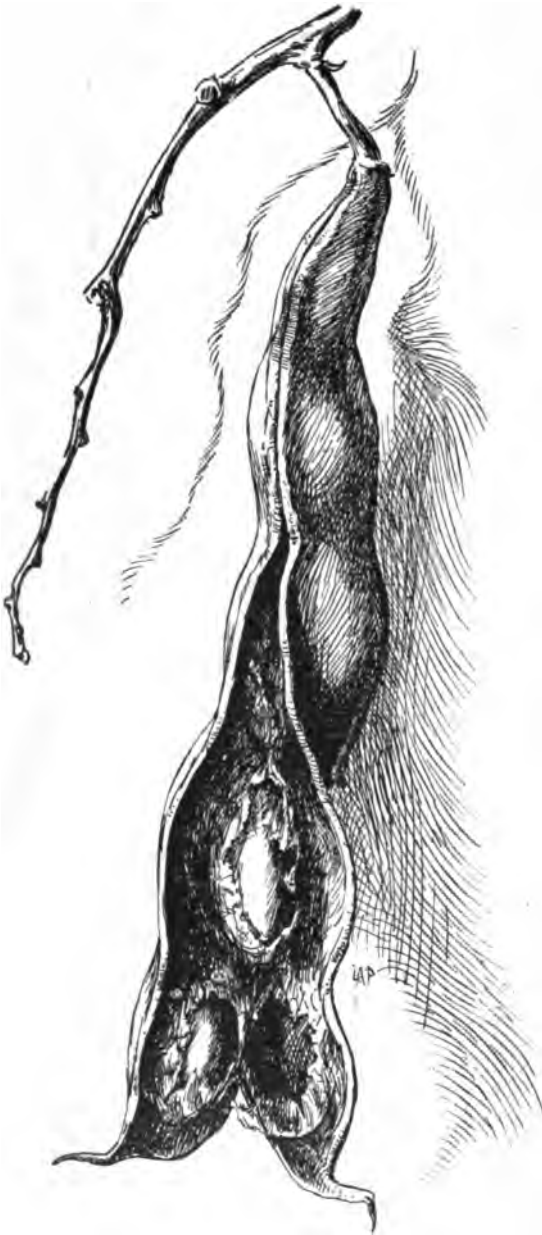
"I am acquainted only with the three kinds of bush Lima, which are now catalogued by every seedsman, viz.: Henderson, Dreer and Burpee. The dwarf or bush character of all these three seems to be well fixed, and only in the Burpee do I find an occasional reversion to the original twining form. With the exception of this change in habit of growth, the bush Limas have



30—Bareldes Bush Lima (natural size.)



29.—Burpee Bush Lima.



31.—*Barteldes Bush Lima* (natural size).

all the advantages and faults of the original variety. Henderson possesses all the characteristics of the ordinary pole Sieva ; Dreer, those of the ordinary Dreer Pole Lima, and Burpee, those of the old Large Lima.

" If I lived in a locality with seasons too short for the development of the large lima beans, I would surely plant Henderson which is as early, as productive, but also as small in foliage and individual seed, as the pole Sieva. This bush Sieva is as easily grown as any ordinary dwarf bean, and will do well on any ordinary good corn land. I can see no more reason to grow the pole form of the Sieva than to seek for and grow a pole form of the Early Valentine, or of any of our common snap beans, except perhaps for ornament, variety or curiosity. The plants are usually so well loaded with pods, that one can gather the latter by handfuls. On the other hand the single beans are small, and not

equal in quality to the larger Limas. The dry bean also is easily grown, since the pods shed water well, and protect the seed from becoming spotted.

"Dreer Bush Lima equals Dreer Improved Pole Lima in quality, being superior in this respect to all other beans which I have ever grown. Its habit of growth, however, is far from being ideal. The pods grow closely together near the ground, and are in danger of becoming badly soiled, and of rotting long before the beans are fit for use. It will need improvement in this respect long before it will ever become popular, notwithstanding its high quality.

"Burpee Bush Lima leaves nothing to be desired in form of plant except breeding out the slight tendency reverting to the climbing habit. The plants are reasonably productive, the pods filled with from one to four very large beans, and the quality of the latter good enough for anybody. The ground should be rich and warm, and kept well cultivated. A good crop can then be grown even in a pretty dry season. But this is applicable to pole Limas with equal force.

"For some years I have been looking for accidental crosses between these bush Limas, and for the purpose of supplying the most favorable conditions for their production, have planted large patches with mixed seed ; but thus far have failed to find a single cross."

REVIEW.

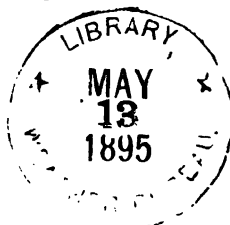
The dwarf or bush forms of the Lima beans are, as a class, acquisitions to the vegetable garden. They belong to two distinct species, *Phaseolus lunatus* and *P. multiflorus*. The single variety derived from the latter species—the Barteldes—seems to have little to recommend it for cultivation in New York. The dwarf offspring of *Phaseolus lunatus* are of three general types : 1. The Sieva dwarfs, which are the earliest and most productive and of which the most serviceable variety appears to be the Henderson ; 2. The potato Lima dwarfs, represented by the Thorburn or Dreer, which is of the highest quality, and in all ways desirable ; 3. The large Lima dwarf, the Burpee, which has been the leading single variety upon our own grounds, on account of the large size and high quality of its beans, and it is evidently as well adapted to general field culture as the earlier or smaller-seeded varieties. All these dwarf Limas—Henderson, Jackson, Thorburn and Burpee—are worth growing either for home or market.

L. H. BAILEY.

VEGETABLE GARDENING PUBLICATIONS OF CORNELL UNIVERSITY EXPERIMENT STATION.

Bulletins which are marked with an asterisk are out of print. Articles which are published in miscellaneous bulletins, along with other matter, are inclosed in parenthesis.

- *Bulletin 7 (1889). On the Influences of Certain Conditions on the Sprouting of Seeds.
- *—10 (1889). Tomatoes.
- *—15 (1889). (The Onion Mould. Prevention of Potato Rot. A Point in the Cultivation of Root Crops. The Orange Melon. Influence of Soil upon Peas. The Influence of the Depth of Transplanting on Heading of Cabbages. Influence of Depth of Sowing on Seed Tests. Do Old Seeds of Cucurbits give Shorter Vines than Recent Seeds? Tests of Patent Germinator.)
- *—21 (1890). Tomatoes.
- *—25 (1890). (The Effect of Removing Tassels on the Prolificacy of Corn. The Forcing of Beans. Influence of Latitude upon Potatoes. The Influence of the Depth of Transplanting upon the Heading of Cabbages. The Paper Flower Pot. Experiences in Crossing Cucurbits.)
- *—26 (1891). Experiences with Egg Plants.
- *—28 (1891). Experiments in the Forcing of Tomatoes.
- 30 (1891). Some Preliminary Studies of the Influence of the Electric Arc Light upon Greenhouse Plants.
- *—31 (1891). Forcing of English Cucumbers.
- *—32 (1891). Notes of Tomatoes.
- *—37 (1891). (Physalis, or Husk Tomato. Pepino. Chorogi. Spanish Salsify. The Influence of the Depth of Transplanting upon the Heading of Cabbages.)
- 40 (1892). Removing Tassels from Corn.
- 41 (1892). On the Comparative Methods of Steam and Hot Water for Greenhouse Heating.
- 42 (1892). Second Report upon Electro-Horticulture.
- 43 (1893). Some Troubles of Winter Tomatoes.
- *—45 (1892). Tomatoes.
- 49 (1892). (Note on the Cercospora of Celery Blight. Corn-Detasseling Experiment. A new Maize and its Behavior under Cultivation. Behavior of Some Egg Plant Crosses. The Wild Potato of the Mexican Region. Do Fertilizers affect the Quality of Tomatoes? Substitute for Glass in Greenhouse Roofs.)
- 53 (1893). Edema of the Tomato.
- 55 (1893). Greenhouse Notes.
- 61 (1893). (A New Food Plant,—*Stachys Floridana*. The Mole-Plant. Garden Docks. Recent Varieties of Tomatoes. Tomato-Potato Grafts. A Potato Preserver.)
- *—67 (1894). Some Recent Chinese Vegetables.
- 78 (1894). The Cabbage Root-Maggot, with [notes on the Onion Maggot and Allied Insects.



V7
3826

Bulletin 88.

April, 1895.

**Cornell University Agricultural Experiment Station,
AGRICULTURAL DIVISION.**

Early Lamb Raising



By G. C. WATSON.

**PUBLISHED BY THE UNIVERSITY,
ITHACA, N. Y.
1895.**

ORGANIZATION.

BOARD OF CONTROL:

THE TRUSTEES OF THE UNIVERSITY.

STATION COUNCIL.

President, JACOB GOULD SCHURMAN.

Hon. A. D. WHITE,	-	-	-	-	Trustee of the University.
Professor I. P. ROBERTS,	-	-	-	-	President State Agricultural Society.
Professor I. P. ROBERTS,	-	-	-	-	Agriculture.
Professor G. C. CALDWELL,	-	-	-	-	Chemistry.
Professor JAMES LAW,	-	-	-	-	Veterinary Science.
Professor A. N. PRENTISS,	-	-	-	-	Botany.
Professor J. H. COMSTOCK,	-	-	-	-	Entomology.
Professor L. H. BAILEY,	-	-	-	-	Horticulture.
Professor H. H. WING,	-	-	-	-	Dairy Husbandry.
Professor G. F. ATKINSON,	-	-	-	-	Cryptogamic Botany

OFFICERS OF THE STATION.

I. P. ROBERTS,	-	-	-	-	Director.
E. L. WILLIAMS,	-	-	-	-	Treasurer.
H. W. SMITH,	-	-	-	-	Clerk.

ASSISTANTS

M. V. SLINGERLAND,	-	-	-	-	Entomology.
GEO. C. WATSON,	-	-	-	-	Agriculture.
G. W. CAVANAUGH,	-	-	-	-	Chemistry.
E. G. LODEMAN,	-	-	-	-	Horticulture.
MICHAEL BARKER,	-	-	-	-	Horticulture.

Office of the Director, 20 Morrill Hall.

Those desiring this Bulletin sent to friends will please send us the names of the parties.

BULLETINS OF 1895.

84. The Recent Apple Failures in western New York.
85. Whey Butter.
86. Spraying of Orchards.
87. The Dwarf Lima Beans.
88. Early Lamb Raising.

EARLY LAMB RAISING.

During the last three years experiments have been made to compare the merits of Shropshires and Horned Dorset sheep as breeds to produce "Hot house" or winter lambs. In the summer of 1891, the College of Agriculture and the Experiment Station owned but few sheep suitable for this trial but it was thought best to begin the test with the available number and continue it through a number of years. Additions were to be made to the flock as opportunity offered and suitable quarters could be provided. In carrying out this test, particular reference has been given to the growth of grade lambs of these two breeds for the reason that the great majority of early lambs sent to the New York market are a cross of thoroughbred males on grade merino ewes. These ewes as bought or bred by the early lamb raiser have more or less blood of the improved mutton breeds but still not enough to place them in any class other than grade merinos. In this connection it may be of interest to note the development of the merino sheep and the causes which made this breed a favorite for so many years.

As the great improvement of the merino was made by American breeders, they became admirably adapted to the climate and to the conditions under which the farmer of the Middle and New England states kept this class of stock.

The ability of the American merino to thrive on rather scanty pastures, the bleak hillsides and the half cleared fields has been a potent factor in subduing and improving much land that would otherwise have remained unproductive. These sheep have done a most excellent service for the American farmer and with a greater profit for the investment and labor bestowed than could have been obtained by any other breed at the time these improvements were made. This together with the reluctance of the sheep owners to give up that which has served them well has kept the merino sheep in the state for a number of years at very little or even no profit.

In the trials made in raising early lambs from merino or grade merino ewes it has been found that these sheep respond quickly in

milk production to extra care and food and that they are well adapted for the purpose of early lamb raising.

Formerly merino sheep were kept with great profit for the production of wool alone but with the great decline in the value of wool during the last few years, it became necessary for the sheep owners to dispose of them, or in some way so conduct the breeding and feeding that the meat product would equal or exceed that of the wool in value. Those who found it necessary to exchange the wool breed for some of the larger so-called middle breeds learned that the methods pursued with the merinos profitably would not give satisfactory returns with these English mutton breeds; the business had to be learned anew and frequently discouragement instead of success was the result which eventually led to the abandonment of sheep husbandry.

While the merinos would thrive in large flocks on rather indifferent pasture, providing it was not too wet during the summer, dry feed and a suitable grain ration for the winter; it was soon found that the distinctively mutton breeds would not produce as desirable mutton on this food as the same breeds produce in England, where succulent food is fed throughout the year. It is now generally admitted that the best flavored, juicy mutton cannot be produced by the food and care heretofore given by the American farmer to merinos. The consequent failures and discouragements have led sheep owners to produce a product not before attempted, early lambs.

The sheep owners throughout the state have pursued somewhat different courses in striving to produce the best product of this kind, and without doubt the method adopted by this station will differ from those of many successful early lamb raisers.

Since a few ewes have been purchased each year since the season of 1891, it has been the custom to sell each year nearly all of those purchased the year before, retaining only a few of the best, those that raised the best lambs. In making this selection it has been found that the ewes that raised the best lambs, were the best milkers, and have been the ones as a rule that bred the earliest. In studying closely the records of all the ewes, the thoroughbreds as well as the grades, this fact has been clearly brought out, that there is a close connection between early breeding and great milk

production. A great difficulty met with in raising lambs for the early market is to get the ewes to breed early. With ordinary precautions a few ewes of almost any flock that is at all suited for this purpose, will breed early and will fatten good lambs, but when early lamb raising is undertaken on a somewhat extensive scale, it is desirable to have a considerable number of ewes lamb at about the same time, in order that one or more pens of ewes may be fed the same ration. If the lambs are all dropped within a short period the labor of caring for them will be much less than if they are dropped throughout a long period. In feeding all classes of stock it is desirable to have the animals that are fed together as uniform as possible and particularly is this essential in lamb raising. Whenever the ewes go into winter quarters in good flesh, very little or no grain and but few roots should be fed before lambing time, this will enable the owner to carry his ewes through a critical period with less trouble than if grain and roots are fed liberally before the lambs are born. Whenever grain and roots are fed in considerable quantities to ewes before lambing, those ewes that are heavy milkers will give the owner more or less trouble on account of their udders becoming hard and inflamed from an undue secretion of milk. Of course this means that the best ewes are likely to be injured and a loss entailed which cannot be afforded, particularly as the remedy is so simple. As the ewes recover from lambing, grain may be fed in small quantities at first but increased as fast as the condition and character of the ewes will safely permit. The best results have been obtained, every thing considered, in feeding grain as described and forcing the ewes to their utmost for a period of four to eight weeks after lambing. At this time extra grain and care will bring greater returns than any other time during the year; the profit derived from this increased flow of milk is not directly proportional to the total yield. A little extra food may bring the lamb into prime condition and cause it to sell for the highest market price, while the same lamb without this increased nourishment would be only in fair condition and sell in the market for not more than two-thirds the price of prime lambs.

It is of the utmost importance that the lambs be well fattened. No matter how large and thrifty a lamb may be, it will not sell for the highest price if it is not fat.

During the time that the ewes are being forced to their greatest capacity for milk, the lambs should receive equally as careful attention in the way of inducing them to eat as much food as possible. It has been found that these lambs will consume more grain food if a change is frequently made so that a variety is offered them. In changing this food, it has been observed that the lambs will eat a certain kind of grain with considerable relish for a day or two and then seem to tire of it and consequently consume less; as soon or even before this stage has been reached, if a change in the grain ration is made, it has been found that the lambs will consume a large amount of grain without loss of appetite.

A little sugar sprinkled on ground feed will help materially to teach the lambs to eat, and in order to still further facilitate this the grain should be so placed that it is within easy reach of the lambs at all times and where it cannot be disturbed by the ewes. It will not take the feeder long to ascertain what kinds of grain are relished best. Different kinds of ground feed are readily eaten but particularly are those relished where corn and oats form a considerable portion of the mixture. Whole wheat and whole oats are readily eaten.

Tables I and II, give in detail the growth of thoroughbred Shropshire and Dorset lambs in the experiment of 1891-92. The weights are given in pounds.

TABLE NO. I.—RECORD OF GROWTH—THOROUGHbred SHROPSHIREs, 1892.

Number of Lamb.	Weight at birth.	Weight 2d week.	Weight 3d week.	Wt. 4th week.	Weight 5th week.	Weight 6th week.	Weight 7th week.	Weight 8th week.	Weight 9th week.
	lbs. oz.								
2	10-1	16.75	22.5	30.	33.5	39.5	44.5	45.5	51.
5	8-5	11.75	14.75	19.	22.	23.5	27.5	31.5	34.5
17.....	10-13	13.5	15.5						
18	9-8	11.5	14.						
Average	9-11	13.87	16.68	24.5	27.75	31.5	36.00	39.00	42.75
Average gain			8.31	5.88	8.20	3.75	4.50	8.00	8.75

Average gain for whole time, 3.91.

TABLE NO. II—RECORD OF GROWTH—THOROUGHBRED DORSETS, 1892.

Number of lamb.	Weight at birth.	Weight 2d week.	Weight 3d week.	Wt. 4th week.	Weight 5th week.	Weight 6th week.	Weight 7th week.	Weight 8th week.	Weight 9th week.
	lbs. oz.								
3.....	11-8	17.25	23.5	30.5	36.5	42.	47.	49.5	56.
4.....	8-14	13.50	18.25	24.	30.5	36.5	42.5	45.5	51.
7.....	11-6	13.	17.5	23.					
Average Wt	10-9	14.58	19.75	25.8	33.5	39.25	44.7	47.5	53.5
Average gain			5.17	6.05	6.8	5.75	5.45	2.80	6.0

Average gain for whole time, 5.86.

While the number of lambs of each breed was small the difference in gain was so great that it is worthy of notice. The Dorset lambs were the largest at birth and gained more each week throughout the whole period of feeding than did the Shropshires, although the greatest gain was made after the fourth week. The Dorset ewes had the appearance of being heavier milkers than the Shropshires, and the lambs consequently were stronger and made more growth.

Tables III and IV show the weekly gain of thoroughbred Shropshire and Dorset lambs for 1892-93. From these tables it will be seen that as in the former year the Dorsets made the greater gain. While the number of Shropshire lambs in this test were larger than the Dorsets it must not be inferred that the Shropshires could have made as good a record as the Dorsets had the best been selected, for the very best did not equal the average of the Dorsets.

In all the tests both the ewes and the lambs were given all the food they would consume; the food given the two breeds was the same in quality but oftentimes differed considerably in quantity. The Dorset ewes consumed more food than the Shropshires and their appetite seemed less affected by changes in the weather than was the case with the Shropshires. From experiments in feeding these two breeds for three years it was noticed that the Dorsets were the best feeders; not only did they stand forced feeding better, but were less affected by unfavorable atmospheric changes.

TABLE NO. III.—RECORD OF GROWTH—THOROUGHBREED SHROPSHIRE, 1893.

Number of Lambs.	Weight at Birth.	Weight 1st Week.	Weight 2d Week.	Weight 3d Week.	Weight 4th Week.	Weight 5th Week.	Weight 6th Week.	Weight 7th Week.	Weight 8th Week.	Weight 9th Week.	Weight 10th Week.	Weight 11th Week.
12	8.	12.34	15.20	18.12	23.80	27.84	30.20	32.56	36.62	38.60	41.74	45.79
20.....	4.75	7.34	10.66	14.20	16.76	20.24	23.54	27.56	32.60	34.23	38.81	41.82
21.....	5.70	7.70	10.82	13.56	14.90	15.90	17.62	19.96	20.90	24.00	27.75	31.19
23.....	5.40	5.52	7.34	9.84	12.30	14.90	18.24	19.94	19.10	20.88	23.09	23.60
24.....	7.46	8.94	13.26	16.98	19.74	22.60	26.14	28.10	31.70	35.08	41.20	43.67
30.....	8.40	9.80	13.58	17.36	20.40	24.60	28.42	31.18	33.92	38.18	40.70	
32.....	5.93	9.30	12.60	19.08	18.80	21.30	21.62	24.62	28.40			
Average.....	6.61	8.70	11.92	16.16	18.70	21.05	23.68	26.56	29.08	31.82	35.54	37.21
Average gain		2.19	3.22	3.24	3.54	2.85	2.63	2.88	2.49	2.68	3.72	2.70

Average for whole time, 2.87.

TABLE NO. IV.—RECORD OF GROWTH—THOROUGHBREED DORSETS, 1893.

No. of lamb.	Weight at birth.	Weight 1st week.	Weight 2d week.	Weight 3d week.	Weight 4th week.	Weight 5th week.	Weight 6th week.	Weight 7th week.	Weight 8th week.	Weight 9th week.	Weight 10th week.	Weight 11th week.	Weight 12th week.
1.....	9.46	15.22	18.85	24.55	28.96	33.30	38.85	42.84	47.76				
2.....	11.54	17.80	23.32	28.34	32.70	36.75	41.76	46.26	50.40	54.90	59.94	60.22	64.46
3.....	10.55	15.00	19.44	23.00	27.88	31.90	37.00	41.90	47.74	52.52	56.64	60.64	64.84
Average.....	10.51	16.00	20.58	26.29	29.84	33.98	39.20	43.66	48.68	53.71	58.29	60.48	64.65
Average gain		5.49	4.53	4.76	4.55	4.14	5.22	4.46	4.94	4.64	4.58	2.14	4.22

Average for whole time 4.47.

Tables V and VI give the growth of lambs from thoroughbred males and grade merino ewes.

TABLE NO. V.—RECORD OF GROWTH—GRADE SHROPSHIRE, 1893.

No. of lamb.	Weight at birth.	1st week.	2d week.	3d week.	4th week.	5th week.	6th week.	7th week.	8th week.	9th week.	10th week.	Weight 11th week.
9.....	7.90	9.78	11.94	15.40	18.94	21.16	24.56	26.66	29.60	33.10	37.00	39.20
10.....	9.10	8.20	9.94	13.50	15.30	17.86	20.22	22.70	25.90	28.74	30.10	31.40
11.....	8.80	10.66	14.12	18.66	23.00	25.94	29.16	32.90	36.80	41.46	45.54	47.94
13.....	8.36	10.96	13.50	15.12	18.46	21.66	23.44	27.16	27.14	29.68	32.50	35.96
14.....	8.90	11.68	14.54	17.94	20.20	22.38	25.34	28.54	30.26	30.36	32.74	35.25
15.....	10.00	13.60	18.00	21.30	23.36	26.78	29.56	33.72	35.20	37.50	39.90	45.30
16.....	8.20	8.60	12.52	16.42	19.12	22.70	26.66	28.20	31.23	31.00	34.30	34.52
17.....	10.36	12.16	15.82	19.58	23.84	26.86	29.94	32.10	35.40	37.70	40.65	42.77
19.....	10.16	15.34	20.42	25.18	29.30	32.94	36.70	42.80	44.46			
25.....	7.00	10.60	15.18	18.26	21.64	26.16	28.80	33.10	35.10	38.88	38.79	
26.....	7.52	10.92	14.82	17.56	20.05	22.70	24.00	28.60	30.60	33.30	35.94	
Average.....	8.75	11.18	15.52	18.08	21.20	24.28	27.12	30.58	32.82	35.94	38.74	39.04
Average gain		2.88	4.89	2.56	8.12	8.08	2.84	8.46	2.80	2.92	2.80	2.88

Average gain for whole time, 2.66.

TABLE NO. VI.—RECORD OF GROWTH—GRADE DORSETS, 1893.

Number of lamb.	Weight at birth.	1st week.	2d week.	3d week.	4th week.	5th week.	6th week.	7th week.	8th week.	9th week.	10th week.	Weight 11th week.
4.....	9.92	14.60	18.34	21.20	24.64	28.54	33.06	37.20	42.14	45.30	49.30	53.12
5.....	9.62	11.50	15.26	18.84	23.10	27.80	32.76	37.74	40.44	44.62	49.30	53.12
6.....	12.48	16.38	20.30	22.14	26.64	31.10	36.52	41.80	44.62	49.30	53.12	57.94
7.....	11.54	13.80	17.20	19.76	24.14	28.88	31.20	33.84	34.22	34.66	37.60	40.74
8.....	11.40	16.00	21.30	26.34	31.96	36.52	41.70	46.36	49.72	53.12	57.94	62.76
18.....	5.40	9.24	12.72	15.96	19.06	23.10	26.80	31.00	34.68	37.43	40.58	44.18
31.....	12.38	16.40	20.64	24.18	27.70	30.74	33.80	36.90	41.10	44.18	47.26	50.34
Average.....	10.89	18.99	17.96	21.20	25.80	29.52	33.69	38.69	40.88	40.51	42.49	46.98
Average gain		8.60	8.97	8.24	4.10	4.20	4.17	4.14	8.24	2.68	8.59	8.18

Average for the whole time, 8.64.

It will be noticed that the grade Dorsets made a much better growth than the Shropshires.

In selecting ewes for these two flocks care was taken to have the flocks as near alike as to age, breeding and general appearance as it was possible to make them. Whenever the ewes selected for these two flocks were those that were retained from the previous years' purchase, their previous record was taken into account.

Tables VII and VIII give the date of birth, weight at birth and record of growth of Grade Shropshire and Grade Dorset lambs of 1893-4. A considerable larger number of ewes were used in this experiment than in the experiment of the previous year. It will be noticed here also, that so far as the growth of the lambs are concerned, the grade Dorsets show a considerable gain over that of the shropshires. The weight of the lambs at birth of the two lots do not differ materially, yet the average gain per week for the whole time of the dorsets over that of the Shropshires is considerable, and of great importance, if the highest market prices are to be secured. The ewes of these two lots were of equal age, size and general appearance, also in breeding so far as their appearance would indicate. Nearly all of these ewes were purchased of a large breeder of merino sheep who disposed of them on account of their advanced age.

These ewes were good size, many of them weighing from 90 to 110 pounds when in good condition. They were hearty and as a rule, were able to consume a fairly liberal grain ration. It must be remembered however, that these sheep had never before been subjected to a forced feeding for large milk production, and consequently gave a smaller quantity of milk than they would have given had their capacity been developed by liberal feeding calculated to produce this effect for several years previous.

The question has been asked if corn silage can be substituted for roots in the ration for ewes when winter lambs are the chief object. This question is of considerable importance to every early lamb raiser who practices ensilageing corn for his dairy. If corn silage will take the place of beets or turnips as a food for this class of sheep, considerable expense can be saved where silos are in use, by feeding the silage as a succulent food instead of roots, since a little extra corn be grown and put in the silo under these conditions, and at a less expense, than the same feeding value of roots can be grown and harvested.

TABLE NO. VII.—RECORD OF GROWTH—GRADE SHROPSHIRE, 1894.

Number of lamb.	Date of birth.	Weight at birth.	Weight 1st week.	Weight 2d week.	Weight 3d week.	Weight 4th week.	Weight 5th week.	Weight 6th week.	Weight 7th week.	Weight 8th week.	Weight 9th week.	Weight 10th week.
7.....	Dec. 28	9.80	11.94	15.68	19.80	23.13	27.10	30.50	35.22	40.	47.50	48.90
8.....	Dec. 31	8.	7.78	10.94	11.20	13.60	15.90	19.60	22.82	27.18	31.16	36.70
9 ..	Dec. 31	8.40	8.20	10.70	12.30	14.56	17.	20.80	22.66	26.52	31.90	37.20
10 ..	Jan. 7	10.03	10.94	13.24	15.80	17.24	21.14	24.46	29.32	34.36	40.10	41.50
13 ..	Jan. 9	11.40	14.88	18.90	22.44	26.50	31.10	35.24	37.30	40.10	45.10	
17.....	Jan. 11	9.10	10.40	13.80	16.44	19.	21.18	24.86	28.50	32.60	34.50	37.60
18.....	Jan. 12	11.20	13.84	18.90	24.44	28.30	33.40	39.12	43.72			
21.....	Jan. 27	9.62	10.84	13.90	17.64	21.62	25.	29.60	39.50	44.		
22	Jan. 30	12.10	15.90	19.22	24.48	27.58	30.60	34.40	38.30	44.10		
23	Jan. 30	8.10	11.30	14.40	17.84	21.83	25.30	28.40	31.70	33.59	38.50	43.88
24	Jan. 31	9.10	13.50	17.46	21.14	25.14	28.80	31.40	35.50	39.40	41.90	45.60
33.....	Feb. 11	9.74	9.74	14.56	18.46	22.70	25.80	30.30	34.39	37.		43.52
35	Feb. 13	10.60	14.82	17.	20.	23.20	26.70	29.40	31.41	37.82	42.42	
37	Feb. 14	10.20	12.36	15.50	19.	22.50	26.70	30.19	33.47	34.46	36.68	
44	Feb. 18	9.10	10.64	13.13	17.	19.60	22.20	24.70	27.20	31.16	33.46	
46.....	Feb. 18	8.70	9.48	12.	16.14	19.40	21.75	24.70	26.91	30.48	33.14	
47	Feb. 19	9.20	9.20	13.30	17.90	21.80	26.	28.40	36.40	37.32		
52	Mar. 9	8.80	10.30	13.90	15.24	18.	20.14	22.04				
59.....	Mar. 16	9.30	9.20	12.98	16.35	19.86	23.30					
Average.....		9.60	11.88	14.71	18.08	21.84	24.69	28.22	32.60	35.68	38.08	41.86
Average gain per week....				2.88	3.37	3.26	3.85	3.58	4.88	3.03	2.40	3.88

Average for whole time, 3.20.

The number of letters of inquiry received at this station seem to demand a better knowledge than we possessed of the feeding value of ensilage in a ration for ewes giving milk. Consequently, two small flocks, consisting of eight grade Merino ewes each were selected with a view to compare the value of corn silage with that of mangel-wurzel. The ewes selected were good sized mature sheep, quite uniform in appearance. From each pen, seven lambs

TABLE VIII.—RECORD OF GROWTH OF GRADE DORSET LAMBS.

Number of lamb.	Date of birth.	Weight										Weight 10th week.
		at birth.	1st week.	2d week.	3d week.	4th week.	5th week.	6th week.	7th week.	8th week.	9th week.	
6.....	Dec. 27	10.	13.40	18.10	24.30	28.90	33.10	38.04	42.26	48.26	52.16	55.50
16.....	Jan. 10	11.	14.60	17.88	20.60	25.	28.82	34.22	37.40	42.80	45.20	
19.....	Jan. 20	11.60	12.60	16.90	21.40	26.16	30.78	35.20	40.10	42.70		
20.....	Jan. 21	10.30	10.96	15.30	19.78	24.12	28.26	31.80	32.90	35.50	40.10	42.40
25.....	Feb. 2	6.80	7.80	12.36	16.60	20.20	24.90	27.10	30.80	34.20	38.21	42.08
29.....	Feb. 7	9.80	11.16	14.18	16.80	20.	22.	22.20	22.60	28.60		
31.....	Feb. 10	10.30	12.16	17.42	21.70	26.76	29.94	32.	33.80	37.10	41.06	
32.....	Feb. 10	11.10	12.02	16.62	21.40	26.	29.74	34.70	39.29	43.	50.18	
36.....	Feb. 13	8.90	11.64	14.50	17.80	20.10	23.30	26.10	29.03	32.04	36.54	
40.....	Feb. 15	10.40	10.70	15.32	18.40	24.30	25.80	29.40	35.39	40.24	44.18	
43.....	Feb. 17	9.40	10.98	13.66	16.90	19.20	22.30	24.50	27.90	30.46	34.58	
45.....	Feb. 18	9.60	10.	13.40	17.50	20.	23.20	26.17	28.81	32.50	34.26	
48.....	Feb. 21	11.60	13.96	18.	21.60	25.10	28.19	31.90	35.46	38.64		
49.....	Feb. 22	8.70	10.20	13.74	17.40	20.24	22.70	26.20	29.46	33.08		
57.....	Mar. 16	7.90	9.94	12.19	14.60	17.12	18.32					
58.....	Mar. 16	6.90	8.	9.54	10.50	12.	13.10					
60.....	Mar. 16	7.10	9.10	11.	13.81	16.62	18.54					
Average.....		9.49	11.18	14.71	18.80	21.87	24.88	29.96	33.23	37.03	41.65	46.66
Average gain per week.....			1.64	3.58	3.59	3.57	3.01	5.08	3.27	3.80	4.62	5.01

Average gain for whole time, 3.95.

were raised. The following tables (IX and X) give the weights each week of each lamb and also their averages and gain. It will be observed that very little difference is shown by these records between the feeding values of these two foods.

Tables XI and XII give the amount of food consumed from January 17th to April 15th by the two lots. The roots were the long red mangel-wurzel, good size, well matured. The ensilage corn was Sibley's Pride of the North, planted in hills three feet

apart each way, and cut and put in the silo when an average ear was just beginning to glaze. The corn was a heavy crop, well eared and nearly all of the ears were put in the silo with the stalks.

TABLE IX.—RECORD OF GROWTH—EWES FED ROOTS, 1893.

Lamb No.	Weight at birth.	Weight 1st week.	Weight 2d week.	Weight 3d week.	Weight 4th week.	Weight 5th week.	Weight 6th week.	Weight 7th week.	Weight 8th week.	Weight 9th week.	Weight 10th week.	Weight 11th week.
7.....	11.54	13.80	17.20	19.76	24.14	28.84	31.20	33.84	34.22	34.66	37.60	40.74
8.....	11.40	16.00	21.30	26.34	31.96	36.52	41.70	46.36	49.72	29.68	32.50	35.96
13.....	8.36	10.96	13.50	15.12	18.46	21.66	23.44	27.16	27.14	29.68	32.50	35.96
15.....	10.00	12.60	18.00	21.30	23.36	26.78	29.56	33.72	35.20	37.50	39.90	45.30
17.....	10.36	12.16	15.82	17.58	23.84	26.86	29.94	32.10	35.40	37.70	40.65	42.77
19.....	10.16	15.34	20.42	25.18	29.30	32.94	36.70	42.80	44.46			
31.....	12.38	16.40	20.64	24.18	27.70	30.74	33.80	36.90	41.90			
Average.....	10.59	14.08	18.12	21.68	25.58	29.19	32.88	36.12	38.29	84.88	87.66	41.19
Average gain		8.44	4.09	3.51	8.90	8.66	8.14	8.79	2.17	1.89	8.55	8.58

Average for whole time, 8.22.

TABLE NO. X.—RECORD OF GROWTH—EWES FED ENSILAGE, 1893.

Number of lamb.	Weight at birth.	Weight 1st week.	Weight 2d week.	Weight 3d week.	Weight 4th week.	Weight 5th week.	Weight 6th week.	Weight 7th week.	Weight 8th week.	Weight 9th week.	Weight 10th week.	Weight 11th week.
4.....	9.92	14.60	18.34	21.20	24.64	28.54	33.06	37.20	42.14	45.30	49.30	53.12
5.....	9.62	11.50	15.26	18.84	23.00	27.80	32.76	37.74	40.44	44.62	49.30	53.12
9.....	7.90	9.78	11.94	15.40	18.94	21.16	24.56	26.66	29.60	33.10	37.00	39.20
11.....	8.80	10.66	14.12	18.66	23.00	25.94	29.16	32.90	36.80	41.46	45.54	47.94
14.....	8.90	11.68	14.54	17.94	20.20	22.38	25.34	28.54	30.26	30.36	32.74	35.25
16.....	8.20	8.60	12.52	16.42	19.12	22.70	26.06	28.20	31.23	31.00	34.30	34.52
35.....	6.28	5.90	7.02	9.00	10.74	12.82	15.78	18.87	21.87	25.08	28.77	32.01
Average.....	8.51	10.88	13.89	16.78	19.94	22.85	26.78	31.87	35.08	37.64	39.77	42.01
Average gain		1.87	8.01	8.89	8.16	8.11	8.71	8.28	8.21	2.56	8.66	2.28

Average for whole time, 8.18.

The grain fed these two lots consisted of two parts bran, one part corn meal and one part cotton seed meal.

During the time this grain was fed, the sheep had all they would

TABLE XI.—LOT I.

	Hay.	Water.	Roots.	Total Grain.
Jan	326.50	760.5	31 5	
Feb.....	474.5	1391.5	714.	
Mar....	308.	1358.	744.	
Apr.....	138.5	572.	436.	
Total	1247.	4082.	1926.	714.

TABLE XII.—LOT II.

	Hay.	Water.	Ensilage.	Total Grain.
Jan	304.	770.	131.5	
Feb.....	447.	1655.	687.	
Mar.....	288.5	1411.	653.	
Apr.....	97.	685.	285.	
Total.....	1137.	4522.	1757.	762.

readily consume twice a day. The roots and ensilage were fed but once a day in as large quantities as would be readily eaten. The coarser part of the corn stalks in the ensilage was not consumed, and was weighed back and deducted from the amount of ensilage weighed out. The hay was a good quality of mixed hay, largely clover, fed twice a day in such quantities as were readily consumed. In this connection it may be said that good clover hay is one of the requisites to success in raising early lambs. While bean straw or other coarse fodder, rich in nitrogen, may be substituted in part, yet there is no coarse fodder so good as first quality clover hay.

In order to make a more thorough trial of the comparative feeding value of ensilage and roots, the succulent food for ewes rearing early lambs, the experiment of 1893 was repeated. In this trial somewhat larger flocks were taken, otherwise the experiment was carried out in all details the same as the one of the previous year.

Each lot consisted of 16 ewes, and from each pen 15 lambs were raised, one ewe in each lot failed to breed.

Tables XIII and XIV give the record of the growth of the lambs of each lot.

TABLE XIII—RECORD OF GROWTH—EWES FED ROOTS, 1894.

Number of lamb.	Date of birth.	Breed.	Weight 1st week.	Weight 2d week.	Weight 3d week.	Weight 4th week.	Weight 5th week.	Weight 6th week.	Weight 7th week.	Weight 8th week.	Weight 9th week.	Weight 10th week.	Weight 11th week.
6.....	Dec. 27	G. D.	13.40	18.10	24.30	28.90	33.10	38.04	42.26	48.26	52.16	55.50	60.90
8.....	Dec. 31	G. S.	7.78	10.94	11.20	13.60	15.90	19.60	22.82	27.18	31.16	36.70	40.30
9.....	Dec. 31	G. S.	8.20	10.70	12.30	14.56	17.	20.80	22.66	26.52	31.90	37.20	38.90
10.....	Jan. 7	G. S.	10.94	13.24	15.80	17.24	21.14	24.46	29.32	34.36	40.10	41.50	
16.....	Jan. 10	G. D.	14.60	17.88	20.60	25.	28.82	34.22	37.40	42.80	45.20		
17.....	Jan. 11	G. S.	10.40	13.80	16.44	19.	21.18	24.86	28.50	32.60	34.50	37.60	43.50
18.....	Jan. 12	G. S.	13.84	18.90	24.44	28.30	33.40	39.12	43.72	42.70			
19.....	Jan. 20	G. D.	12.60	16.90	21.40	26.16	30.78	35.20	40.10	42.70			
20.....	Jan. 21	G. D.	10.96	15.30	19.78	24.12	28.26	31.80	32.90	35.50	40.10	42.40	
22.....	Jan. 30	G. S.	15.90	19.22	24.48	27.58	30.60	34.40	38.30	44.10			
25.....	Feb. 2	G. D.	7.80	12.36	16.60	20.20	24.90	27.10	30.80	34.20	38.31	42.08	
30.....	Feb. 9	G. S.	10.78	15.12	18.18	23.40	26.24	30.50	32.70	36.50	42.70		
31.....	Feb. 10	G. D.	12.16	17.42	21.70	26.76	29.90	32.	33.80	37.10	41.06		
36.....	Feb. 13	G. D.	11.64	14.50	17.80	20.10	23.30	26.10	29.03	32.04	36.54		
40.....	Feb. 15	G. D.	10.70	15.32	18.40	24.30	25.80	29.40	35.39	40.24	44.18		
Average.....			11.45	15.81	18.89	22.61	26.02	29.84	33.98	38.72	43.82	41.85	45.90
Average gain per week.....				8.86	8.58	8.72	8.41	8.84	4.14	2.74	8.10	2.08	4.05

Average gain for whole time, 8.44.

It will be observed that the lambs of each lot were grade Shropshires and grade Dorsets, and that these were nearly as equally

divided as possible, so that whatever gain one lot may have made over the other was due to the difference of the food consumed and not to any difference to breeding. These sheep were fed ensilage once a day in as large quantities as would be readily consumed.

TABLE XIV—RECORD OF GROWTH—EWES FED ENSILAGE—1894.

Number of lamb.	Date of birth.	Breed	Weight 1st week.	Weight 2d week.	Weight 3d week.	Weight 4th week.	Weight 5th week.	Weight 6th week.	Weight 7th week.	Weight 8th week.	Weight 9th week.	Weight 10th week.
7.....	Dec. 28	G. S.	11.94	15.68	19.80	23.13	27.10	30.50	35.22	40.	47.50	48.90
13.....	Jan. 9	G. S.	14.88	18.90	22.44	26.50	31.10	35.24	37.30	40.10	45.10	
21.....	Jan. 27	G. S.	10.84	13.90	17.64	21.62	25.	29.60	39.50	44.		
23.....	Jan. 30	G. S.	11.30	14.40	17.84	21.83	25.30	28.40	31.70	33.59	38.50	43.88
24.....	Jan. 31	G. S.	13.50	17.46	21.14	25.14	28.80	31.40	35.50	39.40	41.90	45.60
29.....	Feb. 7	G. D.	11.16	14.18	16.80	20.	22.	22.20	22.60	26.60		
32.....	Feb. 10	G. D.	12.02	16.62	21.40	26.	29.74	34.70	39.29	43.	50.18	
33.....	Feb. 11	G. S.	9.74	14.56	18.46	22.70	25.80	30.30	34.39	37.	43.52	
37.....	Feb. 14	G. S.	12.36	15.80	19.	22.50	26.70	30.19	33.47	34.46	36.68	
43.....	Feb. 17	G. D.	10.98	13.66	16.90	19.20	22.30	24.50	27.90	30.46	34.58	
45.....	Feb. 18	G. D.	10.	13.40	17.50	20.	23.20	26.17	28.81	32.50	34.26	
48.....	Feb. 21	G. D.	13.96	18.	21.60	25.10	28.19	31.90	35.46	38.04		
49.....	Feb. 22	G. D.	10.20	13.74	17.40	20.24	22.70	26.20	29.46	33.08		
52.....	Feb. 22	G. S.	10.30	13.90	15.24	18.	20.14	22.04				
60.....	Mch. 16	G. D.	9.10	11.	13.81	16.62	18.54					
			11.48	15.08	18.46	21.90	25.10	28.81	33.12	36.48	41.85	46.12
Average weight												
Average gain per week.....				8.55	8.48	8.44	8.20	8.71	4.81	8.86	4.87	4.77

Average gain for whole time, 8.85.

They learned to like the ensilage almost as readily as they did the beets, and it seemed evident that neither ensilage nor beets had been given these sheep before this experiment was commenced.

Table XV gives the amount of hay, water, roots and grain con-

sumed by the flock fed roots, and table XVI gives the amount of water and food consumed by the flock fed ensilage.

TABLE XV.

	Hay.	Water.	Roots.	Corn and oats.	Meal.
Jan	1368	3248	467	156.5	33
Feb	1549	4307	664	191.	224
Mar	1350	3767.5	661	239.	239
Apr	350	862	240	82.	86
Total	4617	12184	2032	668	622

TABLE XVI.

	Hay.	Water.	Ensilage.	Corn and oats.	Meal.
Jan	1040	2480	433	156	73
Feb	1036	3115	705	188	224
Mar	1130	3595	729	248	248
Apr	460	1179	335	117	125
Total	3666	10369	2202	709	670

The record of the food consumed extends from January 2d to April 19th. It will be noted that the flock given the ensilage consumed somewhat more of this food than was consumed of beets by the beet fed flock. A little more grain was consumed by the sheep fed ensilage than by those fed beets. This difference, however, was hardly great enough to denote a greater appetite caused by the ensilage.

TABLE XVII—RECORD OF SLAUGHTERING GRADE—SHROPSHIRE LAMBS, AND THE PRICES FOR WHICH THEY WERE SOLD, 1893.

Date.	No. of lamb.	Live weight.	Dressed weight.	Loss in dressing.	Age in days.	Amount of sale.
Apr. 18...	11	50.24	34.44	15.80	74	\$6.00
Apr. 18...	19	45.74	33.70	12.04	57	6.00
May 1...	9	46.30	34.76	11.54	88	6.00
May 1...	15	49.	32.50	16.50	82	6.00
May 1...	17	40.30	31.	9.30	73	6.00
Average..		46.31	33.28	13.03	74.8	\$6.00

TABLE XVIII—RECORD OF SLAUGHTERING GRADE DORSET LAMBS AND THE PRICES FOR WHICH THEY WERE SOLD, 1893.

Date.	No. of lamb.	Live weight.	Dressed weight.	Loss in dressing.	Age in days.	Amount of sale.
Feb. 15....	1	48.62	37.16	11.46	58	\$10.00
Mar. 7....	4	45.58	33.82	11.76	65	7.00
Mar. 7....	6	42.80	31.36	11.44	51	8.50
Mar. 27....	5	53.12	38.46	14.69	74	8.00
Mar. 27....	8	49.72	35.81	14.91	55	8.00
Apr. 18....	7	41.54	25.44	16.10	79	3.00
May 1....	31	40.70	31.60	9.10	55	6.00
Average..		46.01	33.87	12.77	62.42	\$7.14

TABLE XIX—RECORD OF SLAUGHTERING GRADE SHROPSHIRE LAMBS, 1894.

Date.	No. of lamb.	Live weight.	Dressed weight.	Loss in dressing.	Age in days.
Feb. 28.....	7	48.90	35.50	13.40	62
Mar. 12.....	8	40.30	28.50	11.80	71
Mar. 27.....	9	43.10	30.04	13.06	86
Mar. 12.....	10	45.10	33.90	11.20	64
Mar. 12.....	13	41.50	28.60	12.90	62
Mar. 27.....	17	45.	32.20	12.80	75
Feb. 28.....	18	45.	34.	11.	47
Mar. 27.....	21	44.	30.82	13.18	59
Apr. 10.....	22	45.80	33.10	12.70	70
Mar. 27.....	23	44.10	31.80	12.30	56
Apr. 10.....	24	45.60	35.	10.48	69
Apr. 10.....	30	42.70	30.80	11.90	60
Apr. 10.....	33	43.52	32.08	11.44	58
Apr. 16.....	35	42.42	29.50	12.92	62
Apr. 30.....	37	47.64	32.34	14.30	75
Apr. 30.....	47	43.64	32.27	11.37	70
Average.....		44.27	31.90	12.29	65

TABLE XX—RECORD OF SLAUGHTERING GRADE DORSET LAMBS, 1894.

Date.	No. of lamb.	Live weight.	Dressed weight.	Loss in dressing.	Age in days.
Mar. 12.....	6	60.90	44.40	16.50	75
Mar. 12.....	16	45.20	31.90	13.30	61
Mar. 12.....	19	42.70	32.80	9.90	51
Mar. 27.....	20	42.40	30.50	12.10	65
Apr. 10.....	26	42.08	30.28	11.80	66
Apr. 16.....	31	40.50	31.80	8.70	65
Apr. 10.....	32	50.18	34.41	15.77	59
Apr. 16.....	40	44.18	30.75	13.43	60
Average.....		46.02	33.85	12.68	63

Tables XVII, XVIII, XIX and XX give the records of weights, dressed weight, loss in dressing, age in days of the Grade Shropshires and Dorset lambs, slaughtered in 1893 and 1894. It will be noticed that the Dorset lambs were slaughtered at a somewhat younger age than were the Shropshires and that their weight dressed was also a little greater than that of the Shropshires. Practically there was no difference in the amount which these two breeds lost in weight by dressing.

Table XXI gives the number of lambs, date of killing, date of sale and price per head. In marketing these lambs, it was found necessary to have them present a neat and inviting appearance when exposed for sale if best prices were to be obtained. Of course size and fatness are of prime importance and it is also equally important that these conditions be obtained early in the life of the lamb before it presents what is known as a "staggy" appearance. As the season advances, it will be found necessary to have the lambs larger than during the first of the early lamb market. The late market seems to demand greater weight than the early market. From several visits at various commission houses in New York it has been learned that care and skill in dressing the lambs and preparing them for market is almost of as much importance as the care and skill in fattening the lamb. Particularly is this true of lambs of ordinary condition. On one visit to a commission house a lot of lambs was noticed for which the commission merchant asked \$3.00 per head and had remained unsold for several days. Assurance was given that this same lot would have met with ready sale at \$6.00 per head had they been properly prepared for the market. In preparing lambs for shipments, certain precautions should be observed.

TABLE XXI.

The following table gives the date of killing, the date of sale and the prices for which the lambs were sold in New York, in 1894.

Date of Killing.	Number of Lamb.	Date of Sale.	Price per head.	Total.
Feb. 28	7	Mar. 1	1 at \$7.	
	18		1 at \$6.50	
				\$13.50
Mar. 12	6	Mar. 14	2 at \$6.	
	8			
	10		2 at \$5.	
	13			
	16		2 at \$4.	
	19			
				\$30.00
Mar. 27	21	Mar. 28		
	23		2 at \$6.	
	20			
	9		3 at \$5.	
	17			
				\$27 00
Apr. 10	26	Apr. 11		
	30			
	24		4 at \$5.50	
	33			
	32		2 at \$5.	
	22			
				\$32.00
Apr. 16	31	Apr. 18		
	35		3 at \$4.	
	40			
				\$12.00
Apr. 30	37	May 2	2 at \$3.	
	47			
				\$ 6.00

It will be seen that the lambs sent early to the market sold for the highest price and in this respect the market for early lambs in 1894 did not materially differ from the markets of other years. As a rule the early market is the best. It is true that the lambs sent at this time are likely to be a little better in quality as those which fatten best are sent first to the market, so naturally the best lambs will be sent to the market a little earlier than the poorer lambs; and when we consider the prices at which early lambs are sold in the New York market during the winter and spring months, this point should be borne in mind. Early lambs are usually sold by the head until Tennessee lambs come to market, then all lambs are sold by the pound. The exact time at which this occurs will vary from year to year.

Sometimes the early lamb market keeps up well until the last of April or even the fore part of May.

The expense of sending lambs to New York will vary greatly throughout the different parts of the state. From points where competing express companies run to New York reasonable express rates may be obtained. From Ithaca to New York the rate is 80 cents per hundred weight.

Sometimes it is of considerable importance that the lambs arrive in New York early in the week. As a rule the Tuesday or Wednesday market is the best. The wholesale market practically closes Friday noon, so lambs ought to reach New York in ample time to be sold before the wholesale market closes.

Some precautions to be taken in dressing lambs.—In order to secure the most perfect bleeding and at the same time to prevent the wool about the head and neck from being soiled it is best to suspend the lamb by the hind feet so that its head will clear the floor by a foot or more.

In bleeding the lamb an opening should be made only on one side of the neck, preferably the left side, immediately back of the head and in front of the cervical vertebra (neck bones). The opening need not be large but it will be necessary to give the knife blade a considerable sweep in order to be sure that the large artery is severed. The stomach and intestines should be removed without disturbing the heart, lungs or liver. As soon as the intestines are removed spreaders should be inserted to give the lamb the best appearance when offered for sale. For lambs



32.—*Nicely dressed.*

weighing from thirty to forty pounds dressed weight, spreaders about 14 inches long will be about the right length. If too long spreaders are used there is danger of breaking the ribs and thereby injuring the appearance. At each



33.—Ready for shipment.

end of the spreader should be made a shoulder and a projecting point; one of these points should be inserted from the outside at the flank near the opening made for the removal of the intestines, the spreader crossing the back diagonally and the point at the other end inserted in a similar manner in the opposite side of the lamb near the chest. In like manner a second spreader is inserted so that the two cross each other forming an X at the back of the lamb. The caul fat should then be fastened by means of two skewers at the thighs and the points of the spreaders, in such a manner that the whole of the meat, not covered with the skin is covered with the caul fat and in this condition the lamb should be allowed to cool. It is of the utmost importance that all of the animal heat be given off before the carcass is wrapped for shipment. Many lambs have reached the market in a bad condition from lack of proper cooling immediately after slaughtering. This is more frequently observed in the spring months during warm weather.

Before shipment each lambs should be wrapped with two separate wrappings, the inner wrapping to be of

plain tough paper or muslin (if muslin is used one yard for each lamb is sufficient). This should be so put on that it will draw tightly over the front of the lamb to prevent breaking and soiling by handling. An outer covering of burlap or sacking should be added before shipment.

From the inspection given a large number of lambs in the New York markets, it was evident that often insufficient provision is made for removing all of the bloody liquid from the chest. In the ordinary way of slaughtering lambs, more or less liquid will accumulate at this point and unless it is removed serious injury to the appearance of the lamb, when shown for sale, is likely to occur. To effectually remove this, an opening should be made with a large knife at the lower part of the chest and kept free until the chest is completely drained. This should always be done while the carcass is yet hanging up.

SUMMARY.

It is of the utmost importance that the lambs be fat.

The market early in the season does not require so large lambs as the late market. The best early market commences as soon as the holiday poultry is out of the way, usually about the middle of January.

Other things being equal, ewes that give the most milk, breed earliest in the season.

The Dorset Horn sheep have bred earlier and fatted better lambs than the Shropshires.

There is practically no difference between beets and ensilage as a succulent food for ewes rearing early lambs.

Dressed lambs should reach the New York market as early in the week as possible; as Saturday is retailers' day, the lambs ought to be sold before Friday noon.

As a coarse fodder for the ewes and also for the lambs there is nothing better than good clover hay. In fact this is one of the essentials to success in early lamb raising.

As a rule ewes respond more liberally to forced feed for milk production the second year than they do the first.

The manner in which the lambs are dressed determines to quite an extent their selling price. Neatly dressed lambs are always preferred to those of like quality poorly dressed.

Ewes should not be forced for milk production until the lambs are a few days old.

Be sure that the animal heat is all out of the carcass before wrapping up for shipment; particularly is this of the utmost importance in warm weather.

An opening should be made to remove the blood from the chest before shipment.

GEORGE C. WATSON.

50.679

V7

C82b

UNIV. OF MICH

JAN 18 1909

Bulletin 89.

May, 1895.

Cornell University Agricultural Experiment Station.

AGRICULTURAL DIVISION.

FEEDING PIGS.



By G. C. WATSON.

PUBLISHED BY THE UNIVERSITY,

ITHACA, N. Y.

1895.

ORGANIZATION.

BOARD OF CONTROL:

THE TRUSTEES OF THE UNIVERSITY.

STATION COUNCIL.

President, JACOB GOULD SCHURMAN.

Hon. A. D. WHITE,	-	-	-	-	Trustee of the University.
Professor I. P. ROBERTS,	-	-	-	-	President State Agricultural Society.
Professor I. P. ROBERTS,	-	-	-	-	Agriculture.
Professor G. C. CALDWELL,	-	-	-	-	Chemistry.
Professor JAMES LAW,	-	-	-	-	Veterinary Science.
Professor A. N. PRENTISS,	-	-	-	-	Botany.
Professor J. H. COMSTOCK,	-	-	-	-	Entomology.
Professor L. H. BAILEY,	-	-	-	-	Horticulture.
Professor H. H. WING,	-	-	-	-	Dairy Husbandry.
Professor G. F. ATKINSON,	-	-	-	-	Cryptogamic Botany

OFFICERS OF THE STATION.

I. P. ROBERTS,	-	-	-	-	-	Director.
E. L. WILLIAMS,	-	-	-	-	-	Treasurer.
H. W. SMITH,	-	-	-	-	-	Clerk.

ASSISTANTS.

M. V. SLINGERLAND,	-	-	-	-	-	Entomology.
GEO. C. WATSON,	-	-	-	-	-	Agriculture.
G. W. CAVANAUGH,	-	-	-	-	-	Chemistry.
E. G. LODEMAN,	-	-	-	-	-	Horticulture.
MICHAEL BARKER,	-	-	-	-	-	Horticulture.

Office of the Director, 20 Morrill Hall.

Those desiring this Bulletin sent to friends will please send us the names of the parties.

BULLETINS OF 1895

84. The Recent Apple Failures in western New York.
85. Whey Butter.
86. Spraying of Orchards.
87. The Dwarf Lima Beans.
88. Early Lamb Raising.
89. Feeding Pigs.

FEEDING PIGS.

On account of the extremely low price of wheat for the past year a great deal more has been fed to stock than usual, and by men who have had little or no experience in feeding it. In the feeding of wheat as in every other new departure, the lack of facts and reliable data concerning the results of previous work in this line frequently hindered those who had wheat to feed, from obtaining the best results under the circumstances. Particularly was a comparison of the feeding value of wheat with one or more of the most common foods needed to help those to compound a ration who have little knowledge of the chemical composition of feeding stuffs. Until quite recently, comparatively few experiments have been made to determine the feeding value of wheat because the price for flouring purposes prevented its use as a food for animals in a practical way. Now, however, many farmers who raise wheat are confronted with the problem, "can I afford to sell wheat at the market price and buy food for stock?" Of course the character and quantity of the coarse fodder to be fed in connection with the grain, should determine largely whether wheat is the most economical of the concentrated foods to feed with it, but aside from this the question of selling wheat and buying corn meal, oats and bran has been one not easy to solve by those confronted with it. It has been said that farmers in this state should not raise wheat; that at the present prices it can be purchased in the market cheaper than it can be grown on the improved land with high priced labor. While this may be true to a great extent, the fact still remains that this crop has taken its turn in the regular four or five years' rotation and cannot be left out without changing the whole system of farming. In many instances no doubt, the system will eventually be changed, but it will take several years to bring it about. Farmers as a rule are conservative and hesitate to try new departures except in a small way at first. This will be a great influence in continuing the cultivation of wheat in New York State for several years to come,

although the money received for the grain may be insufficient to meet the expenses of raising and marketing the crop. Then too, the wheat straw is often the chief stable absorbent in the grain districts and is of great value for this purpose. As the number of animals on the farms is increasing, particularly in the dairy districts, the question of providing absorbents for the preservation of manure is not always easily solved. In view of all these facts it is safe to assume that wheat will be raised for many years in this state and that a larger portion than formerly will be fed on the farms.

In order to make a comparative test of the value of the wheat product with that of corn as a food for pigs, the food was so mixed that the grain fed of each kind had the same chemical composition, so far as the nutritive ratio was concerned. It was found by mixing twenty-six pounds of gluten feed with one hundred pounds of corn meal that the nutritive ratio of the mixture was practically the same as that of wheat. This mixture was fed to one lot of pigs and ground wheat to another. Each lot received equal amounts of skim milk.

Sept. 25th, 1894, twelve barrows were selected from a uniform lot of thirty pigs, about nine weeks old, and divided into two lots of six each. Lot I was fed ground wheat and skim milk; Lot II, corn meal and gluten in the proportions mentioned above with the same amount of skim milk as Lot I. Twenty-six pounds of skim milk was fed to each lot night and morning until about the 10th of January when the milk was increased to fifty-two pounds at each feeding. Each lot was fed the food indicated until Oct. 10th when the pigs were weighed and the records of the experiment began. The following table gives the total weight, the average weight and the average monthly gain for each lot until February 11th, the time of slaughtering.

TABLE I—RECORD OF GROWTH AND GAIN.

Lot I—Wheat.				Lot II—Corn meal and gluten.		
Date of weighing.	Total weight.	Average weight.	Average gain.	Total weight.	Average weight.	Average gain.
Oct. 10. . .	367	61.1		394	65.7	
Nov. 9.....	628	104.6	43.5	704	117.3	59.8
Dec. 10. . .	966	161.	56.4	1082	180.3	63.
Jan. 10	1294	215.6	54.6	1413	235.5	55.2
Feb. 11.....	1556	259.3	33.9	1701	283.5	48.0
Total gain	1189			1307		

It will be noticed that the greatest difference in the record of growth of these two lots is the greater gain of Lot II. While the greatest gain of each lot was made during the second month of the experiment, the wheat fed lot gained nearly as much during the third month as it did during the second month, but the corn fed lot showed a marked falling off during this time. The difference of growth of these two lots is most marked in the difference of gain; the time when the greatest growth was made was nearly the same for the two lots.

During the time of feeding (from Oct. 10, 1894, to Feb. 11, 1895) each lot consumed 8110 pounds of milk or about 10 pounds per head per day for the whole time. Lot I consumed 3473 pounds of ground wheat and Lot II 2826 lbs. of corn meal and 735 lbs. of gluten feed.

The grain food of these two lots was fed with the milk; the meal and ground wheat was stirred in the milk and fed as a slop. The grain was given in as large quantities as would be readily consumed and varied somewhat from day to day, no record being kept of the amount consumed daily. Water was kept before each lot nearly all of the time, no record being kept of the amount drank.

The following table gives the live weight, dressed weight and the weight of various organs:

TABLE II—LOT I.

No. of pig.	Weight alive.	Weight dead.	Weight dressed.	Weight blood.	Weight heart.	Weight liver.	Weight lungs.	Weight spleen.	Weight stom- ach and intestines.
1	262.5	255.5	222	7.0	.50	3.40	2.60	.34	26.66
2	217.5	212.5	189	4.0	.50	2.83	2.31	.21	18.65
3	256.0	249.5	217	6.5	.60	3.48	2.82	.30	25.30
4	271.0	265.5	231	5.5	.68	4.10	3.04	.28	26.40
5	275.5	271.0	237	4.5	.58	3.98	3.00	.32	26.12
6	273.5	267.5	235	6.0	.72	4.04	2.96	.34	24.44
Average ..	259.3	253.6	221.83	5.583	.596	3.64	2.79	.298	24.595
Per 100 lbs. live wt.	97.847	85.54	2.153	.229	1.4038	1.076	.1149	9.485	
Lot II.									
7	221	218.5	188	2.5	.50	2.90	2.50	.40	24.20
8	319	313	270	6	.64	3.94	3.50	.30	34.62
9	315	308	272	7	.68	3.20	2.52	.40	29.20
10	281	273	236	8	.46	3.20	2.70	.19	30.45
11	260	255	226	5	.36	3.00	2.30	.14	23.20
12	305	297	259	8	.40	3.30	3.14	.14	31.02
Average ..	283.5	277.4	241.83	6.08	.51	3.26	2.78	.26	28.78
Per 100 lbs. live wt.	97.853	85.301	2.145	.179	1.15	.98	.091	10.155	

The total dressed weight of Lot I was 1331 pounds and the average loss in dressing was 14.46 per cent. On the supposition that the pigs at the beginning of the experiment would lose the same per cent. in dressing as the average of all the lots, at the time of slaughtering (16.04 per cent.) there was produced during the time of the experiment 1022.87 pounds of pork. The cost of the grain fed this lot was \$38.20, that is allowing 60 cents per bushel for the wheat and ten cents per cwt. for grinding. Allowing the milk to be worth 15 cents per cwt. the total cost was \$50.37 or \$.049 per pound for the pork.

During the same time and on the same basis Lot II produced 1120.20 pounds of pork at a cost of \$.0456 per pound. The corn

meal was computed at \$23 per ton, the average price for which it sold during this time at the Ithaca mills. Gluten meal was purchased at \$17.50 per ton delivered at Ithaca. It must be remembered that the above calculations are made on the market prices of grain during the experiment and that the price of wheat was unusually low, while the price of corn was considerably above the average for the last four or five years for which it has been sold in the market. Notwithstanding all this, the corn produced pork at a less cost per pound than did the wheat.

In the illustrations, No. 1 represents Pig No. 1 of Lot I and No. 2 represents Pig No. 12 of Lot II. It will be observed that Pig No. 1 represented almost exactly the average in weight for Lot I, and that Pig No. 12 was only a little heavier than the average for Lot II.

From the same lot of pigs from which Lots I and II were taken twelve more were selected and divided into two lots of six each, making the two lots as nearly alike as possible and numbered Lots III and IV.

Lot III was fed corn meal and water, no other food being given from October 10, 1894 to February 10, 1895, the time of slaughtering.

Lot IV was fed two parts corn meal, one part meat scrap, and water. Lots III and IV were the same age and breeding as those described in the previous experiment. The object in feeding these two lots was to compare nitrogenous and carbonaceous rations as a food for pigs, both as to growth of the animals and the comparative amount of lean meat produced by these foods. As these animals were of the same age and breeding, and about the same weight at the beginning of the feeding as the two lots just described, comparisons may also be made with them.

The following records give the growth and gain of Lots III and IV.



34.—Figs fed (1) wheat, (2) corn meal and gluten, (3) corn meal, (4) corn meal and meal scrap.

TABLE III.

Lot III—Corn meal.				Lot IV—Corn meal and meat scrap.		
Date.	Total weight.	Average weight.	Average gain.	Total weight.	Average weight.	Average gain.
Oct. 10	383	63.8		384	64	
Nov. 9	572	95.3	31.5	613	102	38
Dec. 10	737	122.8	27.5	883	147	45
Jan. 10	885	147.5	24.7	1185	197.5	50.5
Feb. 11	1003	167.2	19.7	1421	236.8	49.3
Total gain	620			1037		

From the preceding tables it will be seen that there was great difference in the growth of the two lots, also in the time when the greatest growth was made. Lot III gained the most the first month of the experiment, and each succeeding month the increase in weight was less than for the month before. Although these pigs ate much less food than lot IV yet there was no time when they did not present a thrifty appearance. While they did not make the growth of the other lots, they did not at any time appear stunted or unhealthy.

The following tables give in pounds the live weight, dressed weight, and the weight of various organs at time of slaughtering.

TABLE IV—Lot III.

No. of pig.	Weight alive.	Weight dead.	Weight dressed.	Weight blood.	Weight heart.	Weight liver.	Weight lungs.	Weight spleen.	Weight stomach and intestines.
19	194	189.5	161	4.5	.54	2.64	2.08	.36	22.88
20	167	162	134	5	.60	2.06	1.58	.30	23.46
21	150	145	119	5	.40	2.0	1.60	.30	21.40
22	167	162	138	5	.44	2.10	1.48	.29	19.69
23	147	143	116	4	.42	1.96	1.38	.28	22.96
24	178	175	149	3	.60	2.78	1.48	.38	20.76
Average	167.16	162.74	136.16	4.41	.50	2.31	1.60	.32	21.86
Per 100 lbs. live wt.			81.45	2.632	.299	1.381	.956	.191	13.07

LOT IV.

No. of pig.	Weight dressed.	Weight dead.	Weight alive.	Weight blood.	Weight heart.	Weight liver.	Weight lungs.	Weight spleen.	Weight stomach and intestines.
13	258	252	216	6	.62	4.08	2.60	.34	28.36
14	232	228	195	4	.62	3.40	2.00	.40	26.58
15	237	233	197	4	.82	4.20	3.22	.50	27.26
16	224.5	219.5	188	5	.70	2.74	2.50	.40	25.16
17	222	215	186	7	.50	3.36	1.86	.32	22.96
18	248	242	206	6	.58	4.29	2.56	.32	28.25
Average	236.92	231.6	198	5.33	.64	3.68	2.457	.38	26.43
Per 100 lbs. live wt.			83.572	2.245	.27	1.55	1.03	.16	11.155



35.—(1) *Wheat*, (2) *corn meal and gluten*. Sections showing distribution of fat and lean meat between the fourth and fifth ribs.



36.—(4) *Corn meal and meat scrap*, (3) *corn meal*. Sections through the carcass between fourth and fifth ribs, showing distribution of lean and fat meat.

Lot III consumed 2639 pounds of corn meal which cost \$30.35 and produced dressed pork at \$.061 per pound.

Lot IV consumed 2765 pounds of corn meal and 1382 pounds of meat scrap and produced pork at \$.0686 per pound. The meat scrap fed these pigs was obtained from fertilizer manufacturers and appeared to be ground dried meat with a considerable amount of quite fine bone, and analyzed about 10 per cent. of nitrogen. The excessive cost (\$40 per ton) made this an expensive animal food. It was fed in connection with the corn meal, not so much to determine the cost of meat production as the amount and distribution of lean meat compared with that produced by corn meal alone.

The number of the pig or the section in the illustrations designates the number of the lot from which the pig was taken. It will be seen that while lot IV showed somewhat the largest proportion of lean meat, yet the difference was not very marked, showing that, in this case the very different rations so far as the nitrogen was concerned, produced very nearly the same proportion of lean meat.



37.—Sections through the carcass between the kidney and ham, showing the distribution of fat and lean meat.

Fig. 34 shows a representative pig from each lot as they appeared the day after slaughtering. Lot II made the largest growth, and was somewhat the fattest although there was not a marked difference between Lots I and II.

Lot III made the least growth yet was about as fat as the other lots, the greatest difference being in size.

Lot IV while not any fatter than Lot III made a much better growth; particularly was this noticeable in the length of the animals before slaughtering.

Figures 35 and 36 show sections through the carcasses between the fourth and fifth ribs, and Figure 37, sections between the kidneys and ham. Of all the sections, number 4 shows somewhat the largest proportion of lean meat.

CONCLUSIONS.

Corn meal and gluten gave the greatest growth and produced cheaper pork than ground wheat.

Corn meal and meat scrap produced a somewhat larger proportion of lean meat than did corn meal.

The corn meal and gluten lot had a better appetite and consumed more food than the lot fed ground wheat.

The corn meal lot consumed the least food and made the least growth.

Corn meal and meat scrap produced the largest proportion of lean meat, but not enough more to make it commensurate to the cost of the food consumed.

GEORGE C. WATSON.

V7
C826

F. L. Q.

UNIV. OF MICH.

JAN 13 1909

Bulletin 90.

April, 1895.

Cornell University Agricultural Experiment Station,
HORTICULTURAL DIVISION.

THE CHINA ASTERS;

WITH REMARKS UPON FLOWER-BEDS.



PUBLISHED BY THE UNIVERSITY,

ITHACA, N. Y.

1895.

ORGANIZATION.

BOARD OF CONTROL:

THE TRUSTEES OF THE UNIVERSITY.

STATION COUNCIL.

President, JACOB GOULD SCHURMAN.

Hon. A. D. WHITE,	-	-	-	-	Trustee of the University.
Professor I. P. ROBERTS,	-	-	-	-	President State Agricultural Society.
Professor I. P. ROBERTS,	-	-	-	-	Agriculture.
Professor G. C. CALDWELL,	-	-	-	-	Chemistry.
Professor JAMES LAW,	-	-	-	-	Veterinary Science.
Professor A. N. PRENTISS,	-	-	-	-	Botany.
Professor J. H. COMSTOCK,	-	-	-	-	Entomology.
Professor L. H. BAILEY,	-	-	-	-	Horticulture.
Professor H. H. WING,	-	-	-	-	Dairy Husbandry.
Professor G. F. ATKINSON,	-	-	-	-	Cryptogamic Botany

OFFICERS OF THE STATION.

I. P. ROBERTS,	-	-	-	-	-	Director.
E. L. WILLIAMS,	-	-	-	-	-	Treasurer.
H. W. SMITH,	-	-	-	-	-	Clerk.

ASSISTANTS.

M. V. SLINGERLAND,	-	-	-	-	-	Entomology.
GEO. C. WATSON,	-	-	-	-	-	Agriculture.
G. W. CAVANAUGH,	-	-	-	-	-	Chemistry.
E. G. LODEMAN,	-	-	-	-	-	Horticulture.
MICHAEL BARKER,	-	-	-	-	-	Horticulture.

Office of the Director, 20 Morrill Hall.

Those desiring this Bulletin sent to friends will please send us the names of the parties.

BULLETINS OF 1895.

84. The Recent Apple Failures in western New York.
85. Whey Butter.
86. Spraying of Orchards.
87. The Dwarf Lima Beans.
88. Early Lamb Raising.
89. Feeding Pigs.
90. The China Asters.

CORNELL UNIVERSITY, ITHACA, N. Y., Apr. 10, 1895.

The Honorable Commissioner of Agriculture, Albany.

Sir: Last year this station published a bulletin upon the Cultivated Poplars, with some homeopathic remarks respecting the planting of grounds. It was a departure in our work, although it is clearly within the purview of the federal law that matters of ornamental gardening may receive attention from the experiment stations. A full edition of the bulletin was published, but it was very soon exhausted by the demands of correspondents, whilst the surplus of other bulletins touching upon matters of more immediate economic importance, still remained upon our shelves. The people are evidently interested in matters of taste.

Every rural home is touched by any message which is designed to add to the cheer and contentment of life, and with this conviction I have prepared the following paper. I have ventured to prescribe an allopathic treatment for the dejected conventional flower-bed of farmers' yards. The outlook of the paper is not wholly upon the sentimental side, however, although I have endeavored to treat the subject from the point of view of the amateur or flower-lover. Persons who sell seeds and plants—and their number is legion in western New York—are commercially interested in every effort which aims to extend a love of planting; and persons who buy flower seeds are as much in need of advice as those who buy turnip seeds. The account is submitted, therefore, for publication and distribution under Chapter 230, of the Laws of 1895.

L. H. BAILEY.



38.—*An Artist's Flower-Border.*

The chief beauty of the garden should lie in its flower colors and plant forms, and not in the symmetry of its beds and borders. If our ideas of a perfect garden include any rigid geometrical principles, we would better study nature and let our ideals go! Our ideals, at best, are extremely limited, while nature's realism is immeasurable; she puts so much variety into her reality that she is more beautiful than we can imagine, by sheer force of quantity! We should seek to display the whiteness and purity of the lily in the garden, and not trouble ourselves so much about the brown earth patch from which it grows.—*F. Schuyler Mathews, in The Beautiful Flower Garden.*

THE CHINA ASTERS.

WITH REMARKS UPON FLOWER-BEDS.

It is commonly assumed that many people have no love or appreciation of flowers, but it is probably nearer to the truth to say that no person is wholly lacking in this respect. Even those persons who declare that they care nothing for flowers, are generally deceived by their dislike of flower-beds and the conventional methods of flower-growing. I know many people who stoutly deny any liking for flowers, but who, nevertheless, are rejoiced with the blossoming of the orchards and the purple bloom of the clover fields. The fault is not so much with the persons themselves as with the methods of growing and displaying the flowers.

The greatest fault with our flower-growing is the stinginess of it. We grow our flowers as if they were the choicest rarities, to be coddled in a hotbed or under a bell-jar, and then to be exhibited as single specimens in some little pinched and ridiculous hole cut in the turf, or perched upon an ant-hill which some gardener has laboriously heaped upon a lawn. Nature, on the other hand, grows her flowers in the most luxurious abandon, and you can pick an armful without offense. She grows her flowers in earnest, as a man grows a crop of corn. You can revel in the color and the fragrance, and be satisfied.

The next fault with our flower-growing is the flower-bed. Now, nature has no time to make flower-beds ; she is busy growing flowers. And, then, if she were given to flower-beds, the whole effect would be lost, for she could no longer be luxurious and wanton, and if a flower were picked her whole scheme might be upset. Imagine a geranium-bed or a coleus-bed, with its wonderful "design," set out into a wood or in a free and open landscape ! Even the birds would laugh at it !

What I want to say is that we should grow flowers when we make a flower garden. Have enough of them to make it worth the effort. I sympathize with the man who likes sunflowers. There is enough of them to be worth looking at. They fill the eye. Now show this man ten square feet of pinks, or asters, or

daisies, all growing free and easy, and he will tell you that he likes them. All this has a particular application to the farmer. He grows potatoes and buckwheat and weeds by the acre: two or three unhappy pinks or geraniums are not enough to make an impression.

I suppose that everyone feels that the greatest charm of any landscape in the north is the greensward. It is the canvas upon which every artist-planter attempts to make a picture. But imagine a painter putting a glowing bed of coleuses on his canvas, for a center-piece! The fact is, the easiest way to spoil a good lawn is to put a flower-bed in it; and the most effective way in which to show off flowers to the least advantage is to plant them in a bed in the greensward. Lawns should be large, free and generous, but the more they are cut up and worried with trivial effects the smaller and meaner they look.

But if we consider these lawn flower-beds wholly apart from their surroundings, we must admit that they are at best unsatisfactory. It generally amounts to this, that we have four months of sparse and downcast vegetation, one month of limp and frost-bitten plants, and seven months of bare earth or mud. I am not now opposing the carpet-beds which professional gardeners make in parks and other museums, but desire to direct my remarks to those humble home-made flower-beds which are so common in lawns of country and city homes alike. These beds are cut from the good fresh turf, often in the most fantastic designs, and are filled with such plants as the women of the place may be able to carry over in cellars or in the window. The plants themselves may look very well in pots, but when they are turned out of doors they have a sorry time for a month adapting themselves to the sun and winds, and it is generally well on towards midsummer before they begin to cover the earth. During all these weeks they have demanded more time and labor than would have been needed to have cared for a plantation of much greater size, and which would have given flowers every day from the time the birds began to nest in the spring until the last robin had flown in November.

I wish that instead of saying flower-bed we might say flower-border. Any good place should have its center open. The sides may be more or less confined by plantings of shrubs and trees and

many kinds of plants. This border-planting sets bounds to the place, makes it one's own ; it is homelike. The person lives inside his place, not on it. He is not cramped up and jostled by things scattered all over the place, with no purpose or meaning. Along the borders, against groups, often by the corners of the residence or in front of porches,—these are places for flowers. When planting, do not aim at designs or effects : just have lots of flowers, a variety of them growing luxuriantly, as if they could not help it.

I have asked a professional artist, Mr. Mathews, to draw me the kind of a flower-bed that he likes. It is shown in Fig. 38, at the beginning of this bulletin. It is a border,—a strip of land two or three feet wide along a fence. This is the place where pig-weeds usually grow. Here he has planted marigolds, gladiolus, goldenrod, wild asters, China asters, and—best of all—hollyhocks. Any one would like that flower garden. It has some of that local and indefinable charm which always attaches to an "old fashioned garden," with its exuberant tangle of form and color. Every yard has some such strip of land along a rear walk or fence or against a building. It is the easiest thing to plant it,—ever so much easier than digging the hideous geranium bed into the center of an inoffensive lawn.

There is no prescribed rule as to what you should put into these flower-borders. Put in them the plants you like. Perhaps the greater part of them should be perennials, which come up of themselves every spring and which are hardy and reliable. Wild flowers are particularly effective. Everyone knows that many of the native herbs of woods and glades are more attractive than some of the most prized garden flowers. The greater part of these native flowers grow readily in cultivation, sometimes even in places which, in soil and exposure, are much unlike their native haunts. Many of them make thickened roots, and they may be safely transplanted at any time after the flowers have passed. To most persons, the wild flowers are less known than many exotics which have smaller merit, and the extension of cultivation is constantly tending to annihilate them. Here, then, in the informal flower-border, is an opportunity to rescue them. Then one may sow in freely of easy-growing annuals, as marigolds, China

asters, petunias and phloxes, and the like. One of the advantages of these borders is that they are always ready to receive more plants, unless they are full. That is, their symmetry is not marred if some plants are pulled out and others are put in. And if the weeds now and then get a start, very little harm is done. Such a border half full of weeds is handsomer than the average well kept geranium bed, because the weeds enjoy growing and the geraniums do not. I have such a border, three feet wide and ninety feet long beside a rear walk. I am putting plants into it every month in the year when the frost is out of the ground. Plants are dug in the woods or fields, whenever I find one which I fancy, even if in July. The tops are cut off, the roots kept moist, and even though the soil is a most unkindly one, most of these much abused plants grow. Such a border has something new and interesting every month of the growing season ; and even in the winter the tall clumps of grasses and aster-stems wave their plumes above the snow and are a source of delight to every frolicksome bevy of snowbirds.

The China asters are amongst the best of all the annual garden flowers. They are of the easiest culture, most free of bloom, and comprise a multitude of forms and colors. They are therefore admirably adapted to profuse and generous effects in schemes of planting. They are also worthy of wide attention because they are adapted to many of the purposes for which chrysanthemums are grown, and they can be raised to perfection wholly without the use of glass. They attain their best in the decline of the season, from late August till frost, at a time when many of the annuals and the greater part of the perennials are spent and gone. No garden flowers carry such a profusion of bloom and color down to the very closing in of winter. Last fall our aster border still had blooms when the snows fell in November, and when even the wild goldenrods had waned and died.

The evolution of the China aster suggests that of the chrysanthemum at almost every point, and it is, therefore, a history of

remarkable variations. The plant is native to China. It was introduced into Europe about 1731 by R. P. d'Incarville, a Jesuit missionary in China, for whom the genus *Incarvillea* of the *Bignonia* family was named. At that time it was a single flower; that is, the rays or ligulate florets were of only two to four rows. These rays were blue, violet or white. The center of the flower (or head) was comprised of very numerous tubular yellowish florets. Philip Miller, the famous gardener-botanist of Chelsea, England, received seeds of the single white and red asters in 1731, evidently from France; and he received the single blue in 1736. In 1752 he obtained seeds of the double red and blue, and in 1753 of the double white. At that time there appear to have been no dwarf forms, for Miller says that the plants grew eighteen inches to two feet high. Martyn, in 1807, says that in addition to these varieties mentioned by Miller there had then appeared a "variegated blue and white" variety. The species was well known to American gardeners at the opening of this century. In 1806, M' Mahon, of Philadelphia, mentioned the "China aster (in sorts)" as one of the desirable garden annuals. Bridgeman, a New York seedsman, offered the China and German asters in 1837 "in numerous and splendid varieties," specifying varieties "*alba*, *rubra*, *cerulea*, *striata purpurea*, etc." In 1845, Eley said that "China and German asters," "are very numerous" in New England.

This name German aster records the fact that the first great advances in the evolution of the plant were made in Germany, and the seed which we now use comes largely from that country. The first marked departure from the type, appears to have been the prolongation or great development of the central florets of the head, and the production of the "quilled" flower. This type of aster was very popular forty and fifty years ago. Breck, in the first edition of his "Flower Garden," in 1851, speaks of the great improvement of the aster "within a few years," "by the German florists, and others," and adds that "the full-quilled varieties are the most highly esteemed, having a hemispherical shape, either a pure white, clear blue, purple, rose, or deep red; or beautifully mottled, striped, or edged with those colors, or having a red or

blue centre." About fifty years ago the habit of the plant had begun to vary considerably, and the progenitors of our modern dwarf races began to attract attention. The quilled, high-centered flower of a generation or more ago is too stiff to satisfy the tastes of these later days, and the many flat-rayed, loose and fluffy races are now most in demand, and their popularity is usually greater the nearer they approach the form of the uncombed chrysanthemums.

The China aster had long since varied into a wide range of colors of the cyanic series—shades of blue, red, pink and purple. I do not know what its original color might have been. The modern evolution of the plant is in the direction of habit, and form of flower. Some type varies—generally rather suddenly and without apparent cause—into some novel form, still retaining its accustomed color. The florist fixes the variation by breeding from the best and most stable plants, and soon other colors appear, until he finally obtains the entire range of color in the species. So it happens that there are various well marked races or types, each of which has its full and independent range of colors. The Comet type (see title page and 3, Fig. 48), now the most deserving of the China asters, illustrates these statements admirably. The Comet form—the loose open flower with long strap-like rays—appeared upon the market about 1886 or 1887 with a flower of a dull white overlaid with pink. The pink tended to fade out after the flower opened, leaving the color an unwashed white. The rose-colored Comet next appeared and the blue was introduced in 1890. The first clear white was introduced in America in 1892, coming from Vilmorin of Paris, and the China aster had reached its greatest artistic perfection.

The greatest desideratum yet to be attained in the China aster is a pure yellow flower. There seems to be some general incompatibility between the cyanic and the xanthic, or yellow, series of colors. Yellow of a pure type has not yet been attained in the annual phloxes and many other plants which affect the blues and reds. Yet the chrysanthemum and various other plants combine the two, and I confidently expect that the China aster will eventually do the same. We already have distinct approaches to the yellow in the Lemon Gem, in which the flowers are suffused with

a lemon-yellow tint, and in a yellow quilled variety introduced this year by Burpee as the Yellow Aster. This latter aster is one of the crowned type, having a good yellow center and a border of whitish rays.

In the immense range of color, form, habit and season in the China aster, the flower-lover can find almost any ideal which an annual compositous flower can be expected to satisfy. In earliness,



39.—*Queen of the Market.* The earliest type of China Aster.

there has been a distinct advance in recent years in the introduction of the excellent French variety, *Reine des Halles*, which is known in this country as *Queen of the Market* (Fig. 39; 2, Fig. 48.) This variety blooms early in August at Ithaca, even when the seed is sown out of doors. One of the earliest forms of this type of aster is Burpee's *Queen of Spring*, which will bloom by the middle of July if started in a frame by the middle of April. This *Reine des Halles* type of aster was introduced in 1885 or 1886 by Vilmorin, although it had long been known in the Paris markets, but the stock was controlled by a few persons. This variety also has the freest and most wide spreading habit of growth, and the stems are so long that the variety is very useful for cut flowers.

The Candelabra asters are very like the Queen of the Market in habit, but are later.

In such a range of type, it is impossible to recommend any one of them as superior to all others. If one wants deep and glowing colors, I should recommend the Truffaut asters, variously known as Perfection and Peony-flowered, and this type has a most beautiful pyramidal habit and a high-centered incurved comely flower (Figs. 40, 41).

The shades of red are especially good in this type of aster. Closely allied to this is the Semple strain, which has the distinction of being the only well-marked type of American origin. This type originated with James Semple, of Bellevue, Pennsylvania, who, by continued selection, has brought it to a high degree of perfection. The plant is a tall and robust grower, reaching two and a half and even three feet high, with long and strong stems and very large flowers (often three

and a half inches across) with incurved and often twisted rays. Two colors of this fine aster are now fixed, the pink introduced in 1892 as Mary Semple, and the white, known as Semple White.

40.—Truffaut's
Peony-flowered



For myself, however, I should give the Comet asters the very first place amongst all the various tribes. The habit is dwarf and compact, although free. But the great merit lies in the flat,

soft, spreading long rays, which give the flowers a freedom and novelty of outline and substance which cannot be found in any other aster. I am particularly fond of the great white Comet and of the delicate shades of azure-blue. I should place the Truffaut, Semple and Jewell strains of asters—all of similar type—in the second place. The Jewell aster known as Apple Blossom, has no superior amongst the delicate shades of blush or pink. For the third place, I should hesitate between the Washington and Chrysanthemum-flowered types. The Victorias are generally given a very high rank, and they are one of the most popular strains in England, particularly for pot culture, but they have not behaved so well with me. They seem to be untrue and mixed in type, and last year many of them gave flat open "eyes" or centers. Yet I should place the Victorias fourth or fifth in my list. Beyond these types, it would be difficult to single out one strain as superior to others for purposes of general cultivation.



41.—*Truffaut's Peony-flowered aster.*

All of them have particular merits. The Queen of the Market is desirable for earliness, long stems and graceful habit, and it is popular with florists. The quilled asters are now so far outnumbered by the flat-rayed section that they may almost be classed with the curiosities. They are always useful for variety, and many persons admire their prim form. One of the best of these is the Victoria Needle (Fig. 42), a variety which distinguished itself on our grounds last year by giving the latest blooms of any aster. The Lilliput,—a slim-growing sort with

- small stiff-petalled flowers—is also one of the favorites of the quilled section. Reading Beauty is also an excellent quilled aster.

Another type of quilled aster is represented by the button-headed German Quilled, with its scant fringe of short rays (Fig.



42.—*Victoria Needle*.

43). The best form of this is the Betteridge, an improved strain with large flowers.

Amongst the curious asters are the Crown or Cocardeau, with a rim of dark color and a center of white or light shades (Figs. 44, 45), the Harlequin or party-colored, and the many miniature or tufted sorts, some of which grow only three or four inches high, and bear a close bunch of small dense flowers (see Fig. 47). The very dwarf types are stiff and bunchy, but they are often used for borders, and the plants can be lifted on the approach of frost and put in pots,

where they will continue to hold their flowers for three or four weeks.

It is impossible to construct a satisfactory classification of the China asters. It is no longer practicable to classify the varieties by color. Neither is it feasible to classify them upon habit or stature of plant, for several of the best marked types run into both tall and dwarf forms. Vilmorin, however, still divides the varieties into two groups, the pyramidal growers, and the non-pyramidal growers.* The most elaborate classification is that proposed by Barron, from a study of extensive tests made at Chiswick, England † Mr. Barron has seventeen sections, but they are not co-ordinate, and they are really little more than an enumeration of the various types or classes. After considerable study of the

* *Les Fleurs de Pleine Terre*, 4th ed. 856 (1894).

† *Journal Roy. Hort. Soc.* xi. part i. 15 (1889); xii. part ii. 401 (1890).

varieties in the field and herbarium, I find the following scheme to be the most serviceable for my purpose :

I. Flat-rayed asters, in which all, or at least more than five or six rows of rays, are more or less prominently flat and the florets open.

A. Incurved or ball-shaped.

B. Spreading or reflexed.

II. Tubular or quilled asters, in which all, or all but the two or three outer rows, of florets have prominently tubular corollas.

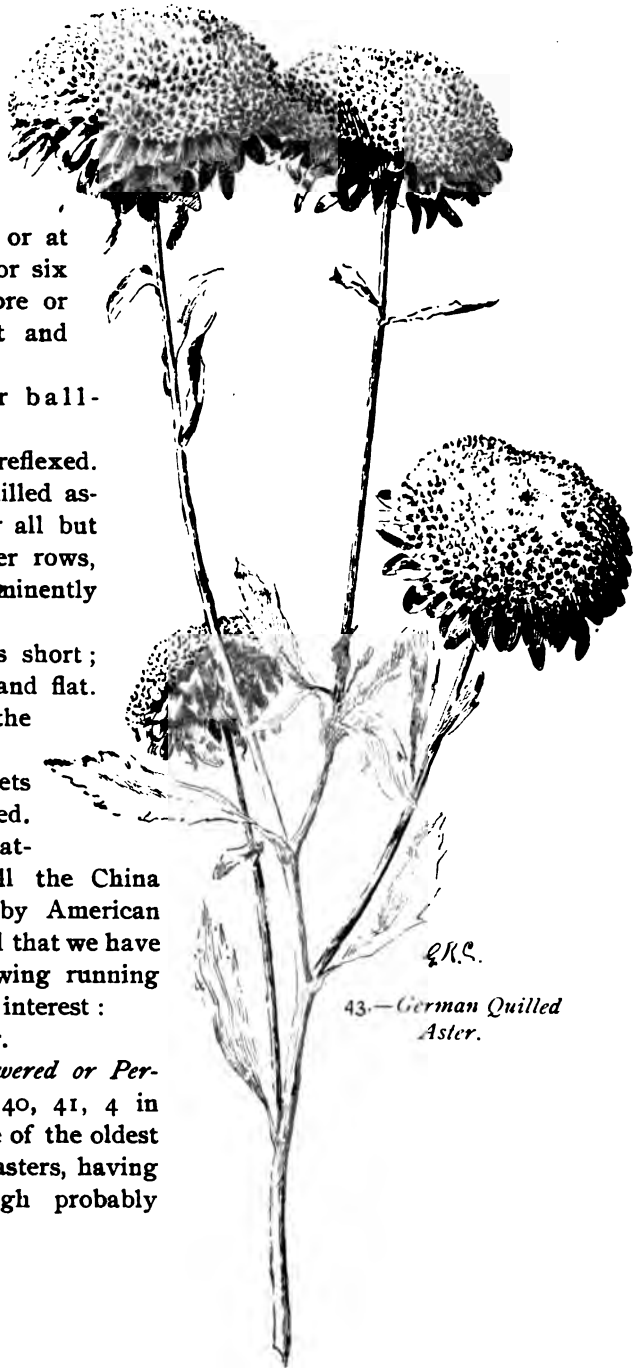
A. Inner florets short ; outer ones longer and flat. Represented by the German Quilled.

B. All the florets elongated and quilled.

I shall make no attempt to describe all the China asters now offered by American seedsmen, nor even all that we have grown, but the following running notes may have some interest :

I. A. *Globe Asters*.

Truffaut, *Peony-flowered* or *Perfection Asters* (Figs. 40, 41, 4 in Fig. 48).—This is one of the oldest types of our modern asters, having been known—although probably



43.—German Quilled Aster.

not in its present excellence—nearly or quite fifty years ago. It was developed by Truffaut of Versailles, who died early in the present year when 78 years of age. The plants are moderately tall, strong and vigorous, more or less pyramidal in habit, with nearly globular often nodding large flowers with the outer petals generally spreading or loose. In many colors. La Superbe is one of the best strains. There is a semi-dwarf form which is excellent. Prince of Wales is one of the globe-flowered Truffauts.

Semple.—Already described, page 150. The New Branching Aster seems to be the same.

Ball-flowered or Jewell.—Mostly of dwarfer habit than Semple, the flowers less incurved than Truffaut, the petals short and the blooms compact and firm. Various colors. Excellent for symmetry of bloom.

Triumph.—As originally introduced by Haage and Schmidt, about 1887, this is a dwarf peony-flowered aster, but much of it now seems to be open-flowered, and Barron classes it with the Chrysanthemum-flowered types. When pure, it is one of the best of the dwarf asters, but it does not appear to be well fixed. It has a very free and graceful habit for a dwarf. Height about eight to ten inches.

I. B. *Flat or Reflexed Asters*.

Chrysanthemum-flowered (1 in Fig. 48).—Plants of various habit and of various merits. Usually characterized by a free and open growth, although there are semi-dwarf forms, and symmetrical well formed flowers with the outer rays much reflexed. A very useful class, in many colors.

Washington.—An offshoot of the last, of medium height, with large, rather flattish flowers, full and symmetrical to the center. Many colors, and little inclined to "run" or sport.

Mignon.—A very fine aster, of medium height, close pleasing habit, the flower full to the center and rather flat, the lower rays not much reflexed. A most interesting feature of one variety is its singular habit of changing color. It opens a white flower with only the faintest tinge of indefinable azure or flesh-color, but gradually passes into a delicate light rose-pink. Flowers small and more regular in shape than the Victorias.

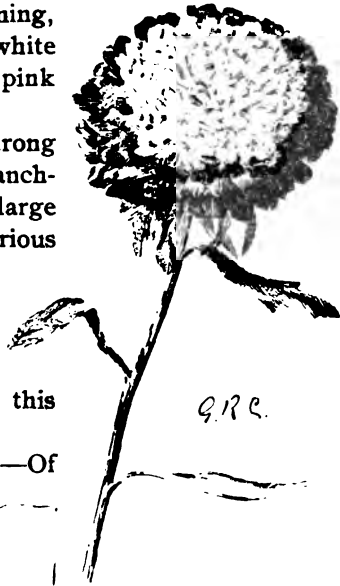
Victoria.—A very popular class of asters, both tall and dwarf.

It is commended for its very free blooming, and for the habit of many of the white strains of changing into azure and pink tints, like the Mignon. (Page 151.)

Emperor, or Giant Emperor.—A strong tall grower, rather late, only slightly branching and bearing three to five very large flowers, of chrysanthemum form; various colors.

Queen of the Market (Figs. 39, 2 in Fig. 48) has been already described (pages 149, 151). *Queen of Spring* and *Queen of the Earlies* are varieties of this type.

Crown or Cocardeau (Figs. 44, 45).—Of



44.—*Crown Aster.*



45.—*Crown.*

medium or semi-dwarf habit (45), early and free flowering. Center of the flower white or nearly so, surrounded by a rim or fringe of variously colored rays. Interesting and very showy. The central florets are somewhat tubular, and suggest the quilled section of asters, with which, perhaps, the type should be classed.

Known also as Double Crowned, Pompon Crown and Cockade.

Comet (Title-page illustration, Fig. 46, 3 in Fig. 48).—Fully described on pages 148, 150. The center of the flower is filled with

short rays, which are sometimes very narrow and twisted. The type still tends to sport, although the greater part of the flowers come true to the ideal form. Fig. 46 shows one of the most frequent departures from the type, with a loose border and a 'single' center.

In this form, the variety approaches the chrysanthemum-flowered type. The Comet asters, in various colors, are amongst the best of all the races for the flower-border, but they are less useful for cut flowers than some of the larger-stemmed and stiffer and rounder flowered types, like Truffaut, Semple, Ball-flowered, and the like.

Imbricated, or Imbricated Pompon.—

This aster, in many colors, is intermediate between the flat-rayed and quilled sections. The rays are all alike or approximately so, short and somewhat concave, springing from a tubular base. The flowers are medium or sometimes small in size, very close and compact, and uniform in shape. The habit is compact,

either dwarf or rather tall. Distinct and desirable.

II. A. *Button-quilled asters.*

German Quilled (Fig. 43).—Described on page 152. There are



many excellent strains of this type, mostly of medium tall and spreading growth, with long stiff stems. In some forms, the flowers are drooping. Many colors.

Dwarf Bouquet (Fig. 47).—Very dwarf and compact asters, growing five to eight inches high, with a terminal bouquet of small very dense flowers with the center florets short and tubular,



47.—*Dwarf Bouquet.*

and a thin border of short flattish rays. Excellent for borders, or formal effects. Many colors.

Shakespeare.—Much like the last, but the flowers more distinctly quilled. These are the dwarfest asters which we have grown, many of the plants never reaching beyond four inches in height. Many colors.

II. B. *Long-quilled or Needle asters.*

Victoria Needle (Fig. 42).—Either medium tall or dwarf asters, with the habit of the Chrysanthemum-flowered type, and the range and brilliancy of coloring of the Victorias, but distinguished by the long quill-like florets, and the absence of rays. Excellent, of its class. (Page 151.)

Lilliput.—Plants tall and strict. Flowers small, the quills slender and compact. Late. Many colors, very pretty. (Page 151.)

The student of a few years hence who consults this paper—if I should be so fortunate as to have a reader then—will be interested to know just what varieties of asters were offered by American seedsmen in the spring of 1895. I have therefore made a list of the varieties, under the names by which they are catalogued. All these many and various types belong to a single species (*Callistephus hortensis**), which is native to Siberia and China, and which is now widely cultivated in temperate climates. The trade names are given, without any attempt to determine synonyms.

Alneer's Perfection Double.	Chrys. flowered—Dwarf, Indigo Blue.
Ball of Fire.	Chrys. flowered—Dwarf, Large Flowered.
Betteridge's Prize.	Chrys. flowered—Dwarf, Light Blue.
Betteridge's Quilled, Mixed.	Chrys. flowered—Dwarf, Orange Rose.
Betteridge's Quilled, Sulphur Yellow.	Chrys. flowered—Dwarf, Mixed.
Blue Danube.	Chrys. flowered—Dwarf, Rose.
Bolitz's Dwarf Bouquet.	Chrys. flowered—Dwarf, Striped.
Boston Florists' White.	Chrys. flowered—Dwarf, White.
Boston Market White.	Chrys. flowered—Tall, Mixed.
Bouquet Dwarf, Crimson.	Cocardeau, or Crown.
Bouquet Dwarf, Mixed.	Comet, Bright Blue and White.
Bouquet Dwarf, White.	Comet, Carmine.
Branching, Crimson.	Comet, Deep Pink.
Branching, Lavender.	Comet, Dwarf.
Branching, Shell Pink.	Comet, Giant White.
Branching, White.	Comet, Indigo and White.
Breck's International Prize.	Comet, Lavender and White.
Candelabra, Red.	Comet, Light Blue.
Candelabra, Rose.	Comet, Lilac.
Candelabra, White.	Comet, Lilac and White.
China.	Comet, Mixed.
Chrysanthemum flowered—Dwarf, Brilliant Rose.	Comet, Peach Blossom.
Chrys. flowered—Dwarf, Crimson.	Comet, Pink and White.
Chrys. flowered—Dwarf, Dark Lavender.	Comet, Purple White.
Chrys. flowered—Dwarf, Fiery Scarlet.	Comet, Rose.
Chrys. flowered—Dwarf, Flesh Pink.	Comet, Rose and White.
	Comet, Snow White.

* The proper botanical name of the China aster, however, is *Callistemma hortense*, Cassini, Dict. Sci. Nat. vi. Suppl. 45 (1817), and Bull. Soc. Philom. 1817, 32. The name *Callistephus hortensis*, both genus and species, dates from 1825. This latter name is accepted by Bentham and Hooker, however (Genera Plantarum, ii. 270), and I therefore used it in the revision of Gray's Field, Forest and Garden Botany, inasmuch as Gray preferred to adhere closely to Bentham and Hooker's work. *Callistemma* has long been in use, with more or less frequency, by horticulturists, and it would seem, therefore, that it should be revived.

Crimson Crown.
 Crimson Wave.
 Diamond.
 Diamond, Dark Crimson.
 Diamond, Deep Carmine.
 Diamond, Deep Violet.
 Diamond, Deep Violet and White.
 Diamond, Crimson and White.
 Diamond, Pink and White.
 Diamond, Purplish Lilac.
 Diamond, Reddish Violet.
 Diamond, Rose.
 Diamond, White.
 Double German.
 Dwarf, Brilliant Rose.
 Dwarf, Fiery Scarlet.
 Dwarf German.
 Dwarf Pyramidal.
 Dwarf Pyramidal Bouquet.
 Dwarf Queen.
 Dwarf Queen, Crimson.
 Dwarf Queen, Dark Blue.
 Dwarf Queen, Large Flowering.
 Dwarf Queen, Light Blue.
 Dwarf Queen, White.
 Eclipse.
 Empress, Bright Blue.
 Empress, Crimson.
 Empress, Mixed.
 Empress, White.
 French, Peony.
 General Jacqueminot.
 Giant Emperor.
 Globe Flowered, Double German.
 Globe Flowered, Pyramidal.
 Goliath.
 Half Dwarf, Multiflora Mauve.
 Harlequin, Mixed.
 Henderson's Marvel.
 Hovey's Florist's Prize.
 Imbricated Pompon, Crimson.
 Imbricated Pompon, Dark Indigo.
 Imbricated Pompon, Lavender Blue.
 Imbricated Pompon, Mixed.
 Imbricated Pompon, "Mourning Aster."
 Imbricated Pompon, Rose.
 Imbricated Pompon, Sky Blue.
 Imbricated Pompon, White.
 Improved Pyramidal Bouquet.
 Improved Quilled.
 Improved Victoria.
 Jewel, Apple Blossom.
 Jewel, Carmine Rose.
 Jewel, Crimson.
 Jewel, Purple.
 La Brilliant.

Lady in White.
 Large Rose-Flowered, Dark Scarlet.
 Large Rose-Flowered, Mixed.
 La Superbe.
 Lemon Gem.
 Leonard's Snowball.
 Lilliput-flowered, White.
 May's Minature.
 Meteor, Bright Crimson.
 Mignon.
 Mignon, Bright Blue.
 Mignon, Carmine Red.
 Mignon, Peach Blossom Pink.
 Mignon, Snow White.
 Mignon, White and Lilac.
 Mignon, White and Rose.
 Miniature Bouquet.
 Mixed Crown.
 New Dwarf Pearl.
 Non Plus Ultra.
 Pearl.
 Pearl Blanche.
 Pearl Rose Crown.
 Pearl Rouge.
 Perfection, Flesh colored.
 Perfection, Light yellow.
 Primrose Pink.
 Prince of Wales.
 Princess Rosalind.
 Pygmæ.
 Pyramidal Harlequin, Purple.
 Queen of Spring.
 Queen of the Earlies.
 Queen of the Market.
 Quilled, or China.
 Reid's German Quilled.
 Reine des Halles.
 Rose.
 Rose, Blue.
 Rose, Dark Red.
 Rose, White.
 Rose-flowered.
 St. Paul Beauty.
 Salzer's Goliath.
 Salzer's Prize Boquet.
 Salzer's White Bouquet.
 Scarlet Needle.
 Schiller, White.
 Semple's Branching.
 Shakespeare, Crimson.
 Shakespeare, Dark Blue.
 Shakespeare, Mixed.
 Shakespeare, White.
 Silver Ball.
 Snowball.
 Snow Queen.
 Sulphur Yellow.

Sutton's Reading Beauty.	Truffaut's Peony Perfection, Dwarf, White.
Triumph, Dark Scarlet.	Uhland Globe.
Triumph, Dark Scarlet and White.	Vaughan's Beauty.
Triumph of the Market.	Vaughan's Fireball.
Truffaut's Peony Perfection, Brilliant Rose.	Vaughan's Improved Victoria.
Truffaut's Peony Perfection, Carmine.	Vesuvius
Truffaut's Peony Perfection, Crimson.	Vick's New Branching.
Truffaut's Peony Perfection, Dark Blood Red.	Victoria, Apple Blossom.
Truffaut's Peony Perfection, Deep Mauve.	Victoria, Bordeaux Red.
Truffaut's Peony Perfection, Light Blue.	Victoria, Dark Scarlet.
Truffaut's Peony Perfection, Mixed.	Victoria, Dwarf Bouquet, Crimson.
Truffaut's Peony Perfection, Pink.	Victoria, Dwarf Mixed.
Truffaut's Peony Perfection, Purple.	Victoria, Dwarf Rose
Truffaut's Peony Perfection, Snow White.	Victoria, Dwarf White.
Truffaut's Peony Perfection, Striped.	Victoria, Cream-Colored.
Truffaut's Peony Perfection, Dwarf, Black-Blue.	Victoria, Crimson.
Truffaut's Peony Perfection, Dwarf, Black Blue and White.	Victoria, Large Flowering.
Truffaut's Peony Perfection, Dwarf, Crimson and White.	Victoria, Light Blue.
Truffaut's Peony Perfection, Dwarf, Light Blue.	Victoria, Needle.
Truffaut's Peony Perfection, Dwarf, Light Blue and White.	Victoria, Needle Perfection.
Truffaut's Peony Perfection, Dwarf, Rose.	Victoria, Peach Blossom.
Truffaut's Peony Perfection, Dwarf, Rose and White.	Victoria, Purple.
Truffaut's Peony Perfection, Dwarf, Shining Dark Scarlet.	Victoria, Striped.
	Victoria, White.
	Washington, Crimson.
	Washington, Light Blue.
	Washington, Mixed.
	Washington, Needle.
	Washington, Peach Blossom.
	Washington, Silver Gray.
	Washington, White.
	White Star.
	White Wave.
	Yellow Aster.
	Zirngiebel's, Double White
	Zulu King.

Respecting the cultivation of these China asters, little need be said. If early flowers are wanted or if the plants are to be grown in pots as specimens for exhibition, the seeds should be sown indoors or in a frame as early as the middle of April, in this latitude. But if the plants are to be grown in borders, it is quite as well to sow the seed in the ground where the plants are to grow. The China aster is essentially an autumn flower, and I have no desire, from the amateur's standpoint, to force it ahead of its season and to make it compete with the flowers of midsummer. We sowed the seeds of about fifty varieties on the 4th of June last year. The soil was rich and kindly—a good loam—and the plants came on with vigor, and, notwithstanding a prolonged drought, every variety gave a profuse bloom throughout September and October, and a few sorts—like Queen of the Market—spent themselves and died before frost came.

China asters do not force well. They generally grow too tall and are too slow in coming into bloom. But experiments in forcing them for winter bloom have not been made to any extent in this country, and it is not improbable that some varieties might lend themselves to this treatment with ease.

There are two or three insects which prey upon the China aster, but they do not appear to be widespread. The most serious difficulty with them is the rust, a fungus (*Coleosporium Sonchiarvensis*) which attacks the under side of the leaf and raises an orange-colored pustule. Timely sprays with the copper fungicides will keep this disorder in check. The Bordeaux mixture discolors the plants, and it is therefore better to use the ammoniacal carbonate of copper. Spray it upon the plants before the fungus appears, and repeat every week or ten days. Use a cyclone nozzle and spray upwards, so as to strike the under sides of the leaves.

ABSTRACT.

This bulletin desires to discourage the formal and geometrical flower-bed, which persists in setting itself into the middle of a quiet and well behaved lawn. It advises that flowers be grown for their own sakes, and not for the bed in which they happen to be placed. It urges the growing of flowers profusely, in a free and graceful way, in borders next rear walks and fences and against groups of larger plants and occasionally about the foundations of buildings. It would use hardy and free-growing plants in preference to the potted and unwilling house-plants, which usually give strained and exotic effects.

The China asters are amongst the best of the annuals for popular use. They are essentially autumn flowers, and little is to be gained by forcing them ahead of their season, except when they are wanted for sale as cut flowers. In central New York, they may be sown as late as the first or even the middle of June with good results, if the soil is rich and if they are given good care. There is a multitude of varieties. For growing in borders, perhaps the best type is the Comet, in various colors. Other excel-

lent races are the Truffaut, known also as Perfection and Peony-flowered, the Semple or Branching, Chrysanthemum-flowered, Washington, Victoria and Mignon, and Queen of the Market. The last is commended for earliness and graceful open habit, and it is one of the best for cut flowers. Many other types are valuable for special purposes. The Crown or Cocardeau is odd and attractive. Amongst the quilled asters, the various strains of German Quilled, Victoria Needle and Lilliput are excellent. The very dwarf tufted asters are well represented in Dwarf Bouquet or Dwarf German, and Shakespeare.

L. H. BAILEY.

1 2 3 • 4 5



4S.—1 (3 flowers), *Chrysanthemum*-flowered; 2, *Queen of the Market*; 3, *Comet*; 4, *Truffaut's Peony*-flowered; 5, *ye olde tyme sorte*.

030,619

N7

C8eb

Bulletin 91.

April, 1895.



Cornell University Agricultural Experiment Station.

HORTICULTURAL DIVISION.



By MICHAEL BARKER.

PUBLISHED BY THE UNIVERSITY,
ITHACA, N. Y.
1895.

ORGANIZATION.

BOARD OF CONTROL:

THE TRUSTEES OF THE UNIVERSITY.

STATION COUNCIL.

President, JACOB GOULD SCHURMAN.

Hon. A. D. WHITE,	-	-	-	-	Trustee of the University.
Professor I. P. ROBERTS,	-	-	-	-	President State Agricultural Society.
Professor I. P. ROBERTS,	-	-	-	-	Agriculture.
Professor G. C. CALDWELL,	-	-	-	-	Chemistry.
Professor JAMES LAW,	-	-	-	-	Veterinary Science.
Professor A. N. PRENTISS,	-	-	-	-	Botany.
Professor J. H. COMSTOCK,	-	-	-	-	Entomology.
Professor L. H. BAILEY,	-	-	-	-	Horticulture.
Professor H. H. WING,	-	-	-	-	Dairy Husbandry.
Professor G. F. ATKINSON,	-	-	-	-	Cryptogamic Botany

OFFICERS OF THE STATION.

I. P. ROBERTS,	-	-	-	-	Director.
E. L. WILLIAMS,	-	-	-	-	Treasurer.
H. W. SMITH,	-	-	-	-	Clerk.

ASSISTANTS.

M. V. SLINGERLAND,	-	-	-	-	Entomology.
GEO. C. WATSON,	-	-	-	-	Agriculture.
G. W. CAVANAUGH,	-	-	-	-	Chemistry.
E. G. LODEMAN,	-	-	-	-	Horticulture.
MICHAEL BARKER,	-	-	-	-	Horticulture.

Office of the Director, 20 Morrill Hall.

Those desiring this Bulletin sent to friends will please send us the names of the parties.

BULLETINS OF 1895.

84. The Recent Apple Failures in western New York.
85. Whey Butter.
86. Spraying of Orchards.
87. The Dwarf Lima Beans.
88. Early Lamb Raising.
89. Feeding Pigs.
90. The China Asters.
91. Recent Chrysanthemums.

CORNELL UNIVERSITY, ITHACA, N. Y., April 20, 1895.

THE HONORABLE COMMISSIONER OF AGRICULTURE, ALBANY,

Sir:—The sudden popularization of the chrysanthemum is one of the marvels of recent horticultural enterprise. The commercial interest in chrysanthemum growing in this state is now very large, and there are many features of the industry which demand attention from experimenters. As a beginning towards the solution of some of the perplexities which beset the growers of the plant, and for the purpose of still further popularizing a worthy industry, we have made a careful test of the leading varieties upon the market in 1894, and have here given an account of the behavior of the most prominent ones. Our collection numbered over 200 kinds. The report is written from the point of view of the florist, rather than the amateur. I submit the paper as a bulletin under Chapter 230 of the laws of 1895.

L. H. BAILEY.

A KEY TO THE CLASSIFICATION OF VARIETIES OF CHRYSANTHEMUMS.

Group A. Large-flowered. Diameter 4 to 10 inches.

Section 1. Incurved.

Florets regularly incurved.

Sub-section 1. Japanese Incurved.

Florets irregularly incurved.

Section 2. Japanese.

Florets straight, spreading, twisted, curled, or drooping.

Section 3. Reflexed.

Florets regularly reflexed.

Sub-section 2. Japanese Reflexed.

Florets irregularly reflexed, or long and drooping.

Section 4. Anemone.

Florets in two series, disk and ray. Disk florets tubular, forming half a sphere in center. Ray florets strap-shaped, horizontal and arrayed around the outside.

Sub-section 3. Japanese Anemone.

Ray florets incurved, reflexed, or drooping.

Group B. Small-flowered or Pompon. Diameter 1 to 2 inches.

Section 1. Pompon.

Flowers formal and diminutive, with short closely packed florets.

Section 2. Anemone Pompon.

Diminutive flowers of the Anemone type.

Group C. Single-flowered. Diameter 1 to 5 inches.

Flowers single.

RECENT CHRYSANTHEMUMS.

Within the past ten years, the chrysanthemum of the florists has risen from a very inferior position, commercially, to one of the greatest prominence in this country. The first regular chrysanthemum exhibition in America was held under the auspices of the Massachusetts Horticultural Society in 1868, but this and the sister society in Pennsylvania awarded prizes for chrysanthemums much earlier. In those days, however, and perhaps for many years previous, the chrysanthemum was treated as a hardy plant, and cultivated in the outdoor gardens. Better flowers and plants came later, with the idea of affording them greenhouse protection, and then we find Dr. H. P. Walcott, of Cambridge, Massachusetts, and Mr. John Thorpe, then of Queens, Long Island, to be the most prominent raisers of seedlings, cultivators and advocates of the chrysanthemum in general.

But the courageous attempts of these and several other persons in various parts of the country, particularly in the vicinity of Boston, Massachusetts, met with only a small share of success. Not, indeed, until the later years of the past decade was anything approaching popular esteem for the chrysanthemum aroused in the American people, and then it was mainly due to a happy speculation on the part of one of our prominent nurserymen. In 1888, Mr. W. A. Manda, then of Cambridge, Massachusetts, now at South Orange, New Jersey, purchased the famous variety, Mrs. Alpheus Hardy, from a Boston florist for the sum of \$1,500—a price unprecedented in the chrysanthemum world. This event, and the subsequent advertising of the variety, did more to render the chrysanthemum an object of public fame in America than all other previous efforts combined. The demand for these plants at once began to grow with leaps and bounds, annual exhibitions sprung into existence in all parts of the country, and many florists and nurserymen created special departments to cover the work of securing new varieties and to select, propagate and dis-

tribute those of greatest merit. Mrs. Alpheus Hardy had been sent here in the first instance from Japan, and numerous other varieties were now imported from that country in the hope of securing something equally valuable. But while many of those importations proved really meritorious under our climatic conditions, none of them reached that high position in the public regard which had been accorded their forerunner.

So many of these varieties imported from Japan and Europe proved to be unsatisfactory, that it soon became evident that if our growers were to have a class of plants suited to their own peculiar needs and climate, they must set about raising them from seeds, crossing the varieties in hand so as to secure offspring of the desired character. This has been done with very marked success, and foremost among those who have given the departure extensive attention and encouragement may be mentioned, Messrs. Pitcher & Manda, of Short Hills, New Jersey; Messrs. Nathan Smith & Son, Adrian, Michigan; Messrs. Peter Henderson & Co., New York; Messrs. E. G. Hill & Co., Richmond, Indiana; Mr. John N. May, Summit, New Jersey; Mr. Hugh Graham, Philadelphia; Mr. T. D. Hatfield, Wellesley, Massachusetts; Mr. J. C. Vaughan, Chicago; Mr. Wm. K. Harris, Philadelphia; Mr. Thos. H. Spaulding, Orange, New Jersey; and Messrs. Fred. Dorner & Son, Lafayette, Indiana. A very large proportion of the imported varieties are weak growers, and they have a tendency to produce imperfect flowers. The outer florets (erroneously called petals) sometimes expand so as to show the center of the flower, and this characteristic renders certain groups of varieties comparatively worthless for commercial purposes, while in other sections (anemones and pompon anemones) the full development of this central disk is considered one of the essentials of a worthy bloom. This defect occurs less frequently in the domestic productions, although unscrupulous dealers occasionally praise inferior varieties to the disadvantage and often serious loss of the purchaser. Great difficulty stands in the way of decreasing the extent of this evil. With some such idea, and to prevent the duplication of names, the American Chrysanthemum Society was organized at Buffalo, N. Y., August, 1889; and the work of that body, especially in the latter particular, has been of great service to the growers.

A promising innovation was made by the society last autumn in establishing local committees to determine the degree of merit exhibited by all new varieties brought to their notice, and to report them worthy or unworthy, as they found them to be. With a testimonial of this character, given by the most competent judges, the meritorious varieties should soon close the market against all others, and for this reason those who are successful in producing good new kinds should in future submit them to some member of the society before trying to dispose of them by the ordinary process of commerce. The present officers of the society are: Mr. E. A. Wood, Denver, Colorado, president; Mr. E. G. Hill, Richmond, Indiana, vice-president; Mr. E. D. Smith, Adrian, Michigan, Secretary; Mr. John N. May, Summit, New Jersey, treasurer.

Great as are the troubles of nomenclature and misrepresentation, there are others of almost equal importance which the society cannot properly regulate, and the undertaking would be much too troublesome for private or commercial growers. Many dealers now issue long annual lists of new kinds from which it is impossible to select the best varieties for local requirements. No effort is spared, in the most expensive and elaborate systems of cultivation, to make these plants produce blooms for the exhibitions of the previous autumn, and the awards then given are at best an imperfect guide for the investor. The average florist for obvious reasons can provide only ordinary conditions, and he desires to know if any of these new varieties will prove better than the older and cheaper sorts under his method of cultivation. Again, some varieties produce the choicest blooms from "crown" buds, while "terminal" buds are the best in others; some bloom late, others early; some are adapted for specimen plants, others for specimen flowers. Then there are new insects and diseases to deal with, and many minor matters bearing on cultivation, the effects of various fertilizers, etc. Hitherto there has been no one to thoroughly investigate these matters for the benefit of the vast number of people throughout the state and country who are financially and otherwise interested. A work of this character has been recently undertaken by the Horticultural Department of Cornell University, and it is hoped in due time to bring about the desired results.

Although late in the season, operations were begun last August, and a record of the results so far obtained will be found in these pages. It is due to the public spirit and generosity of Messrs. Pitcher & Manda, Messrs. Peter Henderson & Co., Mr. John N. May, Messrs. Nathan Smith & Sons, and Messrs. E. G. Hill & Co., that we were enabled to secure for our purposes ample supplies of such of their varieties of 1894 as were in stock at that time. Many others, who promised to contribute during the present season, would have joined in the work last year had our intentions been known to them before their supplies were exhausted.

RECENT VARIETIES.

While a large number of the new varieties put on sale in the United States of late years show no marked improvement on older types, there are still many of them decidedly superior in character. The advance is perhaps most noticeable in the stems, which are dwarf, stout and erect, and well furnished with luxuriant leaves to the base of the flower, as compared with the long, slender and sparsely leaved growth of older kinds. And the blooms in many cases are of larger size and improved form, and better filled with florets of the best texture. Considerable progress has also been made in providing good types of the most desirable colors to bloom at the various seasons, early, medium and late. Mrs. E. G. Hill and Mrs. H. McK. Twombly, for example, are invaluable additions to our earliest varieties, as are Eugene Dailedouze and Titian to the mid-season set, and Challenge, Laredo and Mrs. J. George IIs to the late-flowering sorts. Niveus, Fig. 52, in all essentials comes nearest to the American ideal of a perfect variety.

The tendency to low growth in the stems, while of much utility when blooms for cutting are the main consideration, is of far greater importance in the production of decorative and specimen plants. It is not forgotten that blooms with two or three feet of stem are a necessity in the cut-flower trade, but there is probably little danger of the dwarfing of the plants being carried so far as to render the flowers they produce unmarketable or useless for cutting. Plants for decoration and exhibition can hardly be too dwarf or stocky in growth, and it is in this connection that such

varieties as Golden Ball, which may be developed in excellent form with one-third of the labor and expense usually required in staking and training, will ultimately assert themselves and increase in popularity. Perhaps the one feature of chrysanthemum development which affords little or no indication of progress is the color of the flowers. It is true that a few novel shades have been produced, but these are of such indifferent character that their utility is doubtful, and most of them, from the florist's point of view, are certainly valueless. The most serviceable flowers for decorative purposes, and hence for commercial work, are those of well-defined colors, and in this direction but little has been accomplished in the last few years.

During the past season we grew many of the more recent kinds with a view to arriving at some definite conclusions in these and kindred matters. They were grown side by side in the center (solid) bed of a long-span-to-the-south greenhouse. This bed is sixty feet long by six feet wide, and the prepared compost, resting on a heavy clay bottom, is about twelve inches in depth, the constituents of the mixture being decomposed clay-sod and well-rotted manure, about three parts of the former to one of the latter. It was late in the season when operations were begun, the plants having been placed in position, about ten inches apart, August 9 and 10. When they had fairly started into growth, some three weeks after planting, a light mulching of short barnyard manure was applied, and twice during the season the bed was dressed with a commercial fertilizer, each time scattering about three pounds of the artificial manure over the entire surface of the bed. Manure-water, prepared from unadulterated cow-dung, was given twice a week until the buds began to show color, when all manuring practically ceased. The liquid was applied at first in very weak solution, using a three gallon measure of the solid manure to one hundred gallons of water, and gradually increased in strength till the end. Water was applied as the plants appeared to need it, and after bright days they were sprayed overhead. Each plant was restricted to one stem, which was trained to a bamboo stake, and only one bud, crown or terminal, was allowed to develop on each. As a result of the late planting, the flowering of the plants was generally late, and a number of

them, which were rather small and weakly at the outset, failed to bloom. In the way of comparing the varieties when grown under equal conditions, however, the test was fair and carefully made.

Our notes on the leading varieties which bloomed with us are given in detail. In parenthesis following the name of the plant will be found the name of the disseminator and date of distribution. Then comes a general estimate of the variety, followed by descriptive particulars. Where we had two or more plants of a variety, one was grown to a crown bud and the other to a terminal. These terms are represented by their initials in the notes set back from the margin, which refer to the taking of the buds and their arrival at the stage of full development. The errors in names as received from the dealers were few in number, and apparently due to misplacement of the labels at some time. One plant of Judge Hoitt was received from Messrs. E. G. Hill & Co. under the name of Andes; Messrs. Peter Henderson & Co. and Messrs. Pitcher & Manda supplied Yellow Hammer under the name of Condor; one plant of Mrs. E. G. Hill came from Messrs. Peter Henderson & Co. under the name of Mdme. Ed. Lefort, and Messrs. Pitcher & Manda described some other variety as Elizabeth Bisland in their catalogue of 1894.

NOTES ON SOME RECENT VARIETIES GROWN AT CORNELL, 1894.

- T. *Terminal*—A flower or flower-bud produced by a lateral shoot.
 C. *Crown*—The solitary flower or flower-bud which is sometimes borne at the extremity of the main stem.

Adele Merz (Pitcher & Manda, 1894)—Medium quality. Stem 36 inches high, strong and erect. Flower 6 inches diameter, showing center a trifle. Florets medium width; reflexed; moderately firm in texture and of rich rose color. Syn. Stanley Baxter.

Taken Sept. 26. At best Nov. 10.

American Eagle (Pitcher & Manda, 1894)—Anemone. Medium. Stem 34 inches high, rather weak. Flowers 5 to 6 inches diameter, full and perfect; largest and best to crowns. Ray florets in a single row, horizontal, medium width; white. Disk full and high; florets rosy purple.

T. Taken Oct. 8. At best Nov. 16.

C. Taken Oct. 8. At best Nov. 10.

Andes (Pitcher & Manda, 1893)—Excellent. Stem 27 inches high, stout and erect. Flowers 6 inches diameter, very full and strikingly decorative.

Florets broad, incurved ; the lower ones drooping a little and slightly curled and twisted ; heavy in texture and of rich bronze-yellow color.

C. Taken Oct. 11. At best Nov. 29.

A. T. Ewing (Hill & Co., 1893)—A very beautiful variety. Stem 26 inches high, stout and erect. Flower 6 inches diameter ; full, and very regular in shape. Florets spreading ; broad ; heavy in substance ; ground color white, margined and suffused with brilliant rose.

T. Taken Oct. 16. At best Nov. 14.

Beau Ideal (Hill & Co., 1893)—Very good. Stem 28 inches high, moderately strong and erect, and of equal strength under crowns and terminals. Flowers $5\frac{1}{2}$ inches diameter ; full, and equally good from crowns and terminals. Florets irregularly spreading ; broad ; good in substance and of a bright pink color.

T. Taken Oct. 11. At best Nov. 29.

C. Taken Oct. 30. At best Dec. 13.

Beauty of Exmouth (Godfrey, 1893)—Very good. Stem 32 inches high, and moderately strong and erect. Flowers 6 inches diameter, very full and decorative. Florets twisted and curled in all directions ; medium width ; firm in texture ; pure white. An English seedling.

C. Taken Oct. 8. At best Nov. 8.

Bonnie Marjorie (Pitcher & Manda, 1894)—Medium. Stem 35 inches high, rather weak. Flower $4\frac{1}{4}$ inches diameter, full and of good form. Florets broad ; heavy in texture ; incurved and of pale yellow color.

T. Taken Sept. 26. At best Nov. 11.

Challenge (Hill & Co., 1894)—A choice variety. Stem 20 to 30 inches high, weakest and shortest under terminals, stout and erect under crowns. Flowers massive, 5 to 6 inches diameter ; largest and best from crowns ; very deep and full. Florets partially incurved ; broad ; firm of texture ; light yellow in color.

T. Taken Sept. 28. At best Nov. 29.

C. Taken Sept. 28. At best Nov. 29.

Charles Davis (Davis, 1894)—Extra fine. Stem 27 to 35 inches high, moderately strong and erect, strongest and longest under terminals. Flowers 6 to $6\frac{1}{2}$ inches diameter, very full and graceful ; largest and best from terminals. Florets irregularly reflexed ; broad ; of medium substance and light bronze color. This is of English origin, a sport from Vivian Morel, and one of the few European varieties that do well in this country.

T. Taken Sept. 27. At best Nov. 1.

C. Taken Sept. 28. At best Nov. 6.

Charlotte (Pitcher & Manda, 1894)—Medium quality. Stem 30 to 36 inches high, strong and erect, shortest and strongest under crowns. Flower 5 inches diameter, full and of good depth. Florets regularly incurved ; texture moderate ; medium width ; ivory-white in color.

T. Taken Sept. 26. Flower deformed.

C. Taken Sept. 27. At best Nov. 13.

Clinton Chalfant (*Chalfant*, 1894)—Very good. Stem 25 to 36 inches high, moderately strong and erect, shortest and strongest under crowns. Flower 5 inches diameter, full and perfect; largest and best from crowns. Florets



49.—*Clinton Chalfant*. (Half Size.)

straight; medium width; firm in substance; color bright yellow. A sport from Joseph A. White. Fig. 49.

T. Taken Sept. 28. At best Nov. 28.

C. Taken Oct. 17. At best Dec. 9.

Creole (*May*, 1893)—Very good. Stem 35 inches high, strong and erect. Flower 5 inches diameter, moderately full. Florets irregularly incurved, extra wide, firm in texture, and of deep amaranth color.

T. Taken Oct. 3. At best Nov. 18.

Elizabeth Bisland (*Fitcher & Manda, 1894*)—A typical Japanese variety of high quality. Stem about 45 inches high, rather weak; strongest under terminals. Flowers 7 to 8 inches diameter, crown buds producing those of the



50.—*Eugene Dailedouze. (Half Size).*

larger size; very full and irregular. Florets narrow; light in texture and of canary-yellow color. A grand keeper.

T. Taken Sept. 27. At best Nov. 10.

C. Taken Sept. 13. At best Oct. 30.

Eugene Dailedouze (*Hill & Co., 1894*)—Superlative. Stem 40 to 45 inches high, longest to crowns; stout and rigid. Flower 6 to 7 inches diameter,

crowns larger and fuller than terminals; of great depth. Florets wide and of heavy substance; irregularly incurved; rich orange-yellow. Fig. 50.

T. Taken Oct. 3. At best Nov. 10.

C. Taken Oct. 3. At best Nov. 21.

Garza (Pitcher & Manda, 1894)—Anemone. Very good. Stem 19 to 26 inches high, equally strong under crowns and terminals. Flower 5 inches diameter; very perfect; best blooms from crown buds. Disk full and compact; florets white, tinged light yellow. Ray florets broad, pure white; standing out horizontally.

T. Taken Sept. 26. At best Nov. 9.

C. Taken Oct. 11. At best Nov. 22.

George R. Gause (Hill & Co., 1893)—Very good. Stem 34 inches high; rather weak, though erect. Flower 6 inches diameter; very full and of great depth. Florets irregularly spreading; medium width; light of texture; reddish-bronze color.

T. Taken Sept. 27. At best Nov. 20.

George Schlegel (Pitcher & Manda, 1894)—Poor quality. Stem 49 to 53 inches high; moderately strong and erect; highest and strongest under crowns. Flowers $4\frac{1}{2}$ to 5 inches diameter, largest and best from crowns. Florets wide; well incurved; pure white.

T. Taken Sept. 26. At best Nov. 12.

Georgienne Bramhall (Pitcher & Manda, 1894)—Very good. Stem 36 to 38 inches high; moderately strong and erect; shortest and strongest to crowns. Flowers $5\frac{1}{2}$ to 6 inches diameter; largest and best from crowns; full. Florets broad, irregularly incurved, thick in texture and of pale yellow color.

T. Taken Sept. 26. At best Nov. 15.

C. Taken Oct. 16. At best Nov. 19.

Gettysburgh (Henderson & Co., 1893)—Medium quality. Stem 39 inches high, strong and erect. Flower 5 inches diameter, moderately full. Florets reflexed, whirled in center; medium width; firm in texture; deep crimson.

T. Taken Oct. 8. At best Nov. 13.

Golden Gate (Pitcher & Manda, 1893)—Poor quality. Stem 31 inches high, moderately strong. Flower 5 inches diameter, showing center very much. Florets broad, reflexed, and of light yellow color.

T. Taken Sept. 27. At best Nov. 13.

Golden Hair (Smith & Son, 1894)—Very good. Stem 26 inches high, stout and erect. Flower $5\frac{1}{2}$ inches diameter, moderately full. Florets irregularly incurved; broad; very hairy; of heavy substance and rich golden-bronze color.

T. Taken Oct. 11. At best Dec. 7.

Golden Wedding (Henderson & Co., 1893)—One of the best. Stem 38 inches high, stout and erect. Flower 6 inches diameter; full, and very attractive in form. Florets irregularly incurved; medium width and substance; deep yellow.

T. Taken Oct. 3. At best Nov. 19.

Hon. Thomas Lowry (Pitcher & Manda, 1894)—Inferior. Stem 36 inches high, weak. Flower 5 inches diameter, full. Florets wide, of good substance; pale yellow in color, faintly suffused with rose. The disseminators class it with the hirsute sections in their catalogue of 1894, but the florets show nothing of the hairy character of this group with us.

T. Taken Oct. 3. At best Nov. 5.

Illuminator (May, 1893)—Very good. Stem 45 inches high, stout and erect. Flower $5\frac{1}{2}$ inches diameter, full. Florets spreading informally; broad; medium texture; bright yellow.

T. Taken Oct. 11. At best Nov. 15.

Ingomar (Smith & Son, 1894)—Excellent. Stem 58 inches high, strong and erect. Flower $7\frac{1}{2}$ inches diameter, full and graceful. Florets spreading; medium width and texture; light bronze shade.

T. Taken Oct. 3. At best Nov. 29.

Jessie Godfrey (Pitcher & Manda, 1894)—Very good. Stem 40 inches high, and of medium strength. Flower $5\frac{1}{2}$ inches diameter; very full and of good depth and excellent form. Florets incurved, those in the center whirled; medium width; white, with light traces of pink.

T. Taken Sept. 26. At best Nov. 8.

J. J. Hill (Pitcher & Manda, 1894)—Medium. Stem 42 inches high, stout and rigid. Flowers $5\frac{1}{2}$ inches diameter, very full. Florets reflexed; medium in width and texture; rich golden-yellow.

T. Taken Sept. 26. At best Nov. 15.

Joey Hill (Hill & Co., 1893)—One of the best. Stem 52 inches high, strong and erect. Flower 6 inches diameter, very full, and excellent in form. Florets broad, the lower ones reflexed, those in center midway between erect and reflexed; strong in texture; upper surface rich, dark velvety red, reverse old gold color.

T. Taken Sept. 27. At best Nov. 6.

Judge Addison Brown (Spaulding, 1894)—Very good. Stem 27 inches high, moderately strong and erect, of equal height and strength under crowns and terminals. Flower $4\frac{1}{2}$ to $5\frac{1}{2}$ inches diameter, largest and best from crowns; very full. Florets informally incurved; broad; notched at the tip; strong in substance, and of deep bronzy-yellow color.

T. Taken Sept. 26. At best Nov. 23.

C. Taken Oct. 23. At best Dec. 8.

Judge Hoitt (Hill & Co., 1893)—Anemone. Good and remarkable. Stem 42 inches high, moderately strong, but rather weak-necked. Flower 5 inches diameter, full, and of curious form. Ray florets broad, and disposed in two or three rows. Disk very large and perfect, the florets almost equal to the outside series in length. The entire flower is of a delicate pink shade.

T. Taken Oct. 8. At best Nov. 13.

Katherine Richards Gordon (Pitcher & Manda, 1894)—Exquisite. Stem 32 to 36 inches high, stout and erect, shortest and strongest under crown

buds. Flower 5 to 6 inches diameter; very full; most perfect and largest from crowns. Florets irregularly incurved; medium width and texture; hairy; white in color, beautifully tinged with pink.

T. Taken Sept. 26. At best Oct. 24.

C. Taken Sept. 27. At best Oct. 22.

Laredo (Smith & Son, 1894)—Very good. Stem 29 to 34 inches high, stout and erect, of equal height and strength under crowns and terminals. Flowers $5\frac{1}{2}$ to 6 inches diameter; full; smallest but most perfect from terminals, the crown buds often developing deformed, though larger blooms. Florets informally spreading, broad; firm in texture; deep pink.

T. Taken Oct. 16. At best Dec. 8.

C. Taken Oct. 16. At best Dec. 1.

L'Enfant des deux Mondes (Crozy, 1893)—Very good. Stem 20 to 27 inches high, weakest and longest under terminals, moderately strong and erect under crowns. Flowers 5 inches diameter; full and of good form; best from crowns. Florets well incurved; medium width and texture; pure white and densely hairy. A sport from Louis Boehmer, introduced from Europe.

T. Taken Sept. 27. At best Nov. 13.

C. Taken Sept. 28. At best Nov. 6.

Major Bonnaffon (Dorner & Son, 1894)—Extra fine. Stem 27 to 29 inches high; shortest and moderately strong and erect under crowns, a trifle weak-necked under terminals. Flower 5 inches diameter; very full; faultless in form; equally good from terminals and crowns. Florets strictly and regularly incurved; broad; medium texture and of a beautifully soft yellow shade. Fig. 51.

T. Taken Oct. 11. At best Nov. 29.

C. Taken Oct. 11. At best Nov. 22.

Marie Louise (Witterstaetter, 1894)—One of the best. Stem 31 to 37 inches high, longest and weakest under terminals, strong and erect under crowns. Flower 6 inches diameter; full and very high in center; longest and best from crowns. Florets irregularly arranged; medium width; firm of substance; pure white.

T. Taken Sept. 26. At best Nov. 20.

C. Taken Oct. 3. At best Nov. 24.

Marion Henderson (Henderson & Co., 1894)—Very good. Stem 24 to 26 inches high, strong and erect, strongest and longest under terminals. Flower 6 inches diameter; full, lasting in perfection a long time. Florets disposed in various directions; narrow, and of medium texture and canary-yellow color.

T. Taken Sept. 27. At best Nov. 18.

C. Taken Sept. 28. At best Nov. 1.

Mary Hill (Spaulding, 1894)—Poor quality. Stem 40 inches high, strong and erect. Flower 7 inches diameter. Florets medium width, spreading and showing center; pale pink; with us, not hairy as described in disseminator's catalogue.

C. Taken Oct. 8. At best Nov. 12.

Maud Dean (Hill & Co., 1893)—An excellent flower. Stem 28 inches high, moderately strong and erect. Flower 7 inches diameter, very full. Florets informally incurved; broad; firm in texture; deep pink color.

T. Taken Sept. 27. At best Nov. 21.

Mayflower (May, 1894)—Among the best of the season. Stem 30 to 35 inches high, strong and erect; longest to terminals. Flowers 7 to 8 inches diameter,



51.—*Major Bonnaffon*. (Half Size).

of great depth and exceedingly full; crowns larger than terminals. Florets of medium width, curled and twisted in all directions; creamy white and of good substance.

T. Taken Sept. 27. At best Nov. 17.

C. Taken Oct. 3. At best Nov. 18.

Miles A. Wheeler (Smith & Son, 1893)—Poor quality. Stem 32 inches high, weak-necked. Flower $4\frac{1}{2}$ inches diameter, very full and of good form.

Florets well incurved; broad and of heavy substance; pale yellow, tinged reddish.

T. Taken Oct. 8. At best Nov. 23.

Miss E. H. Kingsley (Pitcher & Manda, 1894)—Medium quality. Stem 26 to 42 inches high, weak-necked; longest and strongest under terminals. Flowers 5 to 5½ inches diameter, rather flat; very full and compact; largest and best from crowns. Florets informally, though closely incurved; medium in width and substance and of a very light pink shade.

T. Taken Sept. 26. At best Dec. 5.

C. Taken Oct. 3. At best Nov. 22.

Miss F. Pullman (Pitcher & Manda, 1894)—Very good. Stem 46 inches high, stout and rigid. Flower 7 inches diameter; very full and of good depth. Florets partially incurved; medium width and of moderate texture; pure white.

T. Taken Oct. 3. At best Nov. 1.

Miss Hattie Bailey (Smith & Son, 1894)—Very good. Stem 44 inches high, stout and erect. Flower 6 inches diameter; very full. Florets spreading and reflexed; broad; strong in texture and of deep bronze color.

T. Taken Oct. 11. At best Nov. 26.

Miss Louise Hartshorn (Pitcher & Manda, 1894)—Poor quality. Stem 37 to 42 inches high, weak; longest and weakest to terminals. Flower 4½ to 5 inches diameter, showing center. Florets incurved; medium width; hairy and of pink color.

T. Taken Oct. 16. At best Nov. 10.

C. Taken Oct. 18. At best Nov. 4.

Miss T. B. Harper (Pitcher & Manda, 1894)—Good flower. Stem 43 inches high; medium strength, holding flower erect. Flower 5 inches diameter; full. Florets incurved; narrow; pure white.

T. Taken Sept. 26. At best Nov. 13.

Mrs. Archibald Rogers (Pitcher & Manda, 1894)—Very good. Stem 40 to 50 inches high, stout and erect; longest under terminals. Flower 5½ to 6 inches diameter; very full. Florets spreading; medium width; heavy in texture and of deep rosy-purple shade.

T. Taken Sept. 26. At best Nov. 1.

C. Taken Sept. 27. At best Nov. 19.

Mrs. Chas. Lanier (Pitcher & Manda, 1894)—Medium quality. Stem 50 inches high, and rather weak. Flower 5 inches diameter; full and of good form. Florets incurved; medium width; moderate texture and bright yellow color.

T. Taken Sept. 26. At best Nov. 16.

Mrs. E. G. Hill (Hill & Co., 1894)—One of the best. Stem 38 inches high, stout and erect. Flower 6 to 7 inches diameter; full, and attractive in form. Florets incurved; medium width; firm in texture and of bright pink color.

T. Taken Sept. 26. At best Oct. 24.

C. Taken Sept. 28. At best Oct. 20.

Mrs F Gordon Dexter (Pitcher & Manda, 1894)—Japanese Anemone. An excellent variety. Stem 36 to 42 inches high; moderately strong and longest to terminals. Flower $5\frac{1}{2}$ –7 inches diameter; full and perfect; best to terminals. Florets pale rose, $1\frac{1}{2}$ inch long. Ray florets 3 to 4 inches long, drooping about the stem; color white. See frontispiece.

T. Taken Sept. 26. At best Nov. 6.

C. Taken Oct. 16. At best Nov. 30.

Mrs. George J. Magee (Pitcher & Manda, 1894)—Excellent. Stem 30 to 40 inches high, stout and rigid, highest under terminals. Flower 6 inches diameter; best from terminals; crowns weak-necked, showing center. Florets well incurved, wide, forming a globular flower of great depth and solidity; heavy in texture; outer surface pale pink, interior a shade darker. Keeps well.

T. Taken Sept. 26. At best Nov. 1.

C. Taken Sept. 27. At best Nov. 6.

Mrs. George M. Pullman (Pitcher & Manda, 1894)—Highly decorative. Stem 42 to 46 inches high, stout and erect; shortest under crowns, rather weak-necked to terminals. Flower 6 inches diameter, 9 inches when florets are held out horizontally. Florets reflexed; very long, drooping about the stem, and showing center of flower; wide; firm in texture and of deep yellow color.

T. Taken Sept. 27. At best Nov. 9.

C. Taken Oct. 3. At best Nov. 25.

Mrs H. McK. Twombly (Pitcher & Manda, 1894)—Very good. Stem 27–30 inches high, somewhat weak under terminals, but strong and erect to crowns. Flower 5 to 6 inches diameter, full; terminals largest and best. Florets incurved; broad; firm in texture; white, delicately shaded pink.

T. Taken Sept. 26. At best Nov. 10.

C. Taken Sept. 28. At best Nov. 1.

Mrs. Howard Rinek (Pitcher & Manda, 1894)—Very good. Stems 44 inches high; strong, but weak-necked. Flower $5\frac{1}{2}$ inches diameter; very full and of perfect globular form. Florets well incurved; wide; strong in texture and somewhat hairy; deep pink on inner surface, silvery pink externally.

T. Taken Sept. 26. At best Oct. 16.

Mrs. James B. Crane (Pitcher & Manda, 1894)—Medium quality. Stem 42 inches high, strong and erect; equally good under crowns and terminals. Flower 5 to 6 inches diameter, moderately full; largest and best from crowns. Florets irregularly incurved; wide; strong in substance and of deep rose color.

T. Taken Sept. 26. At best Nov. 13.

C. Taken Sept. 27. At best Nov. 9.

Mrs. J. George IIs (Sievers, 1894)—A grand variety. Stems 50 to 60 inches high; strong, but owing to the great weight of the flower, not erect; longest and strongest to terminals. Flower 7 to 8 inches diameter, very full; largest

and best from terminals. Florets irregularly incurved; broad; very heavy in texture; pure white.

T. Taken Oct. 11. At best Dec. 4.

C. Taken Oct. 8. At best Dec. 7.

Mrs. Marshall Crane (Pitcher & Manda, 1894)—Very good. Stem 46 inches high, medium strength. Flower 6 inches diameter, full and of good form. Florets incurved; medium width; strong in substance; creamy white.

T. Taken Sept. 26. At best Nov. 11.

Mrs. Mary A. Forepaugh (Pitcher & Manda, 1894)—Very good. Stem 37 inches high, moderately strong and erect. Flower 6 inches diameter, very full and of good shape. Florets regularly incurved; broad; medium texture; delicate pink, tipped yellow.

T. Taken Sept. 26. At best Dec. 5.

Mrs. Sarah Rose (Pitcher & Manda, 1894)—Very good. Stem 43 to 46 inches high, strong and erect to crowns, weak-necked under terminals. Flowers 5 to 6 inches diameter, full and perfect; largest and best from crowns; Florets slightly reflexed; narrow; medium width; pale rose.

T. Taken Sept. 26. At best Nov. 16.

C. Taken Sept. 27. At best Nov. 19.

Mrs. W. H. Trotter (Spaulding, 1894)—Very good. Stem 30 to 36 inches high, strong and erect; strongest and longest under crowns. Flower 5 to 5½ inches diameter, very full and high; largest and best from crowns. Florets spreading; medium width and substance; curiously lacinated at the tip; pure white. The flowers of this variety develop very slowly, and on this account they are often deformed in the center. Flowers from terminal buds are most subject to this weakness.

T. Taken Sept. 27. At best Dec. 6.

C. Taken Sept. 28. At best Dec. 5.

Mrs. W. K. Vanderbilt (Pitcher & Manda, 1894)—Very good. Stem 40 inches high, moderately strong and erect. Flower 5½ inches diameter, quite full. Florets spreading; medium width and texture; pure white.

T. Taken Sept. 26. At best Nov. 22.

Mrs. Wm. Trelease (Pitcher & Manda, 1893)—Excellent. Stem 42 inches high, stout and erect. Flower 7 inches diameter, very full and of good form. Florets reflexed; medium width; slightly hairy and of a deep pink shade.

T. Taken Sept. 27. At best Nov. 20.

Mrs. W. R. Merriam (Pitcher & Manda, 1894)—Very fine. Stem 38 inches high, strong and erect. Flower 7½ inches diameter and of good form. Florets wide and of good substance, the inner ones incurved, those around the outside straight or slightly reflexed. This is by no means a reflexed flower, as the raisers have classed it

T. Taken Sept. 26. At best Nov. 1.

Mutual Friend (Munn Bros., 1894)—An excellent sort. Stem 19 to 24 inches high, moderately strong and rigid; weakest and longest under terminals.

Flower 5 to 6 inches diameter, terminals larger and fuller than crowns. Florets reflexed, irregularly; wide; medium substance; pure white.

T. Taken Sept. 25. At best Nov. 8.

C. Taken Sept. 25. At best Nov. 5.

Niveus (*Smith & Son, 1893*)—One of the best. Stem 36 to 40 inches high, stout and erect. Flower 6 inches diameter, very full; perfect in form.



52.—*Niveus*. (Half Size.)

Florets incurved in center, slightly reflexed around edge; extra wide; strong in texture; pure white. See Fig. 52.

C. Taken Oct. 11. At best Nov. 16.

Pitcher & Manda (*Pitcher & Manda, 1894*)—Very good. Stem 26 to 36 inches high, moderately strong and erect; strongest and shortest under crowns. Flower 5 to 6 inches diameter, very flat and full; largest and best from crowns. Florets straight and stiff; medium width; the outer ones white, tinged pink; those in the center yellowish.

T. Taken Sept. 26. At best Nov. 9.

C. Taken Sept. 28. At best Nov. 20.

President W. R. Smith (Hill & Co., 1893)—Medium quality. Stem 30 to 36 inches high, strong and erect. Flower 5 inches diameter; moderately full; equally good from crowns and terminals. Florets straight and spreading; medium width and substance; pale pink color.

T. Taken Oct. 3. At best Nov. 8.

C. Taken Oct. 3. At best Nov. 13.

R. L. Beckert (Spaulding, 1894)—Very good. Stem 30 to 34 inches high, moderately strong and erect. Flower $5\frac{1}{2}$ to 6 inches diameter; full. Florets loosely incurved, the center series straight; medium width; strong in texture; deep bronze-yellow.

C. Taken Oct. 11. At best Nov. 20.

Robert M. Grey (Pitcher & Manda, 1894)—Poor quality. Stem 46 to 48 inches high, moderately strong and erect; strongest and shortest under crowns. Flower 5 to 6 inches. Florets incurved, showing center very much; medium width and texture; densely hairy, and of an odd though showy reddish tinge.

T. Taken Oct. 11. At best Nov. 13.

C. Taken Oct. 11. At best Nov. 8.

Sayonara (Chandler, 1894)—Medium quality. Stem 38 inches high, rather weak. Flower 6 inches diameter; full, and of good keeping character. Florets spreading, the lower ones drooping about the stem; medium texture; pale sulphur-yellow color.

T. Taken Sept. 28. At best Nov. 10.

Silver Bill (Pitcher & Manda, 1894)—Anemone. Medium quality. Stem 23-26 inches high, rather weak; strongest and shortest under terminals. Flower $3\frac{1}{2}$ to 4 inches diameter, and fairly perfect; largest and best from crowns. Ray florets horizontal, arranged in several rows; narrow; pure white. Disk full and of good form; florets white, tipped yellow.

T. Taken Sept. 26. At best Nov. 5.

C. Taken Sept. 27. At best Nov. 11.

Thomas Emerson (Pitcher & Manda, 1894)—Fairly good. Stem 28 inches high, strong and erect. Flower 6 inches diameter; somewhat loose. Florets incurved; broad; medium substance; bright yellow.

C. Taken Sept. 26. At best Nov. 6.

Titian (May, 1894)—A superlative variety. Stem 36 inches high, stout and erect. Flower 7 inches diameter; very full and of great depth and fine form. Florets broad; reflexed; firm in texture and of a deep rosy pink shade.

C. Taken Oct. 8. At best Nov. 17.

Toucan (Pitcher & Manda, 1894)—Anemone. Poor quality with us. Stem 30 inches high, moderately firm. Flower $3\frac{1}{2}$ inches diameter, poor in form and color. Disk florets yellowish; rays pale red.

C. Taken Oct. 2. At best Nov. 23.

Wanlass (Spaulding, 1894)—Very good. Stem 50 inches high, strong and erect. Flower 5 inches diameter, very full. Florets informally incurved; medium width; solid substance; silvery pink in color, the interior florets tipped yellow.

T. Taken Oct. 11. At best Dec. 6.

W. C. Cook (Pitcher & Manda, 1894)—Medium quality. Stem 48 inches high, rather weak. Flower $5\frac{1}{2}$ inches diameter, moderately full and compact. Florets incurved; wide; good in texture; color deep yellow. Syn. Chas. A. Jessup.

T. Taken Oct. 26. At best Nov. 13.

W. G. Newitt (Hill & Co., 1893)—Very good. Stem 30 inches high, stout and erect. Flower 5 inches diameter, very full. Florets somewhat irregularly disposed, the outer ones reflexed, those in the centre erect or slightly incurved; texture medium; pure white.

T. Taken Oct. 11. At best Nov. 12.

Wm. Seward (Seward, 1892)—Very good. Stem 23 inches high, stout and erect. Flower 6 inches diameter, very full. Florets loosely spreading medium width and texture; dark crimson. European.

C. Taken Oct. 8. At best Nov. 9.

Yellow Hammer (Pitcher & Manda, 1894)—Excellent. Stem 33 inches high; a trifle weak; strongest under crowns. Flower 4 to 5 inches diameter; crowns largest and best. Ray florets of medium width, arranged in single horizontal row; bright yellow. Disk very full and perfect; florets of a deeper yellow shade than rays.

T. Taken Oct. 3. At best Nov. 25.

C. Taken Oct. 10. At best Nov. 23.

METHODS OF CULTIVATION.

Many systems of cultivation are employed, and as each method has its special advantages, that to be adopted must be decided by the individual grower according to his circumstances. The plants are propagated during the spring months, grown in pots for a time, and finally placed in benches or borders under glass. They may also be grown in pots throughout the year, or planted in the open ground for the summer months and transferred to pots early in autumn. The best results are undoubtedly obtainable under pot culture, as witness the marvellous plants and blooms produced by this process in England; and the best plants we have so far seen in this country have been grown in pots. The reason of this is not difficult to trace. The roots of plants in pots are confined to certain limits and beneficial food, and a grower of ordinary experience may readily supply any nourishment which, from the behavior of the plant, appears to be lacking, or withhold any injurious application of water or stimulants. This cannot be accomplished successfully by any other mode of culture. But except in those rare instances where fully developed specimens

are desired for exhibition purposes, exclusive pot culture is not advisable in this country. The heat and drought of our summers render it too expensive.

Where marketable or exhibition blooms are required, beds or benches under glass afford the most economical means of growing these plants. There is, as has been lately evidenced in the horticultural press, some disparity of opinion as to the relative merits of beds and benches. It should be understood that the term bed here applies to a solid mass of earth the sides of which may be defined by boards or masonry, but the body of soil of indefinite thickness, with from six to eight inches of prepared compost on the top. A bench, on the other hand, has bottom and sides restricted, with capacity for a body of soil averaging six inches in depth. Our experience has amply demonstrated that the benches, under proper treatment, give the best results. The condition of the soil, as to moisture and fertility, can be better controlled in the latter; and in this regard bench culture comes nearer the perfection of pot treatment than any other system. One great difference presents itself in that the plants, with roots spreading at will throughout the soil, must be treated collectively rather than individually. This is a drawback of no mean importance where numerous varieties are planted indiscriminately in the same bench, but one which may be eliminated to an appreciable degree by growing the plants of each variety in partially isolated batches, or, as is the common practice in large commercial establishments, by devoting an entire bench to a single variety.

Although hardly so satisfactory as benches, beds have some advantages. A point largely in their favor is their still greater economy. The material and work of a bottom are saved, and this becomes a very important item when the receipts and expenditures are compared. There is a further saving in labor, for the watering of plants in beds does not require such persisted attention as that of those in pots or benches. An experienced grower, by the exercise of good judgment in watering, may often secure blooms in beds fully equal in quality to the best raised on benches.

With regard to the financial side of chrysanthemum growing it must be said that there are at least ten purchasers of moderate priced flowers of medium quality to every one who will demand blooms

of faultless character and pay the highest price for them. The writer has an impression that the proportion in favor of the inferior flowers is on the whole much greater than this, although the assurances given him by retail dealers of long standing in eastern cities do not exceed the degree stated. Some will be inclined to say on the strength of this reasoning that it would not be profitable to grow flowers of the best quality. This would be an erroneous impression, tending to defeat the purpose of these remarks, which is to encourage the best rather than excuse questionable methods, and yet to assure those of inferior opportunity that their position is by no means hopeless. The number of growers who produce lower grade flowers is far in excess of those who can rise to the greater requirements of their profession, and so far there is no reason to believe that the supply of greenhouse products of high quality is greater than the general demand. Poor flowers do not sell to advantage, but there are many profitable grades between the poor and the best. Perhaps the lowest grade of marketable flowers are those obtained from plants grown out of doors during the summer months. These plants are taken up in August and placed in pots or boxes. During the latter part of September, when the nights become chilly, they are removed to a sunny greenhouse, where in due time they bloom profusely. The flowers of such plants, in their natural clusters, are much esteemed by many purchasers; and if the plants themselves have had some little staking and training after potting, they can be sold readily.

INSECTS FRIENDS AND ENEMIES.

The insects most commonly found on chrysanthemums are here named and some descriptions of them and their work, with instructions for the eradication of detrimental kinds, are given to enable the inexperienced to deal with all according to their deserts.

Ants—The little brown ants so common in greenhouses and on plants grown therein are not injurious. Occasionally they appear in such large numbers that their presence is objectionable; but it should be remembered that they are great scavengers, and while working little or no injury to the plants, they clear them of a lot of objectionable matter in the form of dead and dying insects. Their presence should therefore be tolerated.

Black Aphis—Entomologists are undecided about the specific position of the much-dreaded black aphid of the chrysanthemum, although it is apparently one of the commonest of the plant lice of greenhouses. It multiplies with amazing rapidity, and is found on the young shoots and leaves of many cultivated plants, being very partial to chrysanthemums, deforming the foliage and destroying its vitality. It is easily held in check by the frequent application of pyrethrum powder, or by fumigation with tobacco.

Caterpillars—The green caterpillars which abound on chrysanthemums indoors and out, all through the growing season, are very destructive. They live upon the fleshy portion of the leaves, leaving only the thin epidermal covering of the upper surface, and occasionally devouring the leaves bodily. Sometimes they also attack the soft young shoots, treating them in similar fashion. They are easily traced by their work and their blackish excrement, and they should be at once picked off and destroyed. Usually they are found on the under side of the leaves.

Chrysopa—We have a friend in the larvæ of the lace wing fly, of the group of insects known to entomologists under the name of Chrysopa, which is an insatiable enemy of aphids and kindred pests. This larva is of greyish color, and nearly an inch in length. It kills and devours the minor insects in large numbers, and in this respect is certainly one of the best helpers of plant growers. The perfect insect is extremely pretty, having beautiful green lace-like wings and golden eyes.

Green-Fly—Perhaps the most familiar of all greenhouse insects is the aphid commonly known as the green-fly. The young and tender branches of soft-wooded plants are its favorite abode, and where once it gets a footing, it speedily becomes plentiful. The insects feed upon the juices of the plant, which soon shows the result in its sickly appearance and ultimate death. The insects and their deposits also render the foliage and flowers very unsightly even before they have effected any serious injury. Tobacco smoke is the best remedy.

Lady Birds are common everywhere during the summer months, and they sometimes make their appearance in greenhouses in winter and spring. They and their larvæ feed largely on the various aphids, and in this way do valuable work while

they cause no injury to the plants. Sometimes they are very common, and appear to pervade every nook and corner, and at other times it is difficult to find a single specimen. They should never be destroyed.

Mites—Much havoc was made among verbenas some years ago by insects commonly known as mites. This is the two-spotted mite, *Tetranychus bimaculatus*, a close relative of the red spider. It appears to be common now in the greenhouses of many parts of the country, attacking plants of various kinds, chrysanthemums among the number. It is a small, whitish insect, more inconspicuous than the red spider, and affects the plants in much the same way. It is extremely difficult of eradication, and thrives best in a dry atmosphere. If the house and plants are kept constantly damp, the mite does less damage. It can also be despatched with kerosene emulsion. The emulsion should be diluted—twenty-five to thirty parts of water to one of the emulsion—and applied often, say three or four times or even more a month. Two applications made in quick succession will probably annihilate all the fully developed insects on the plants, but the numerous eggs are probably still unaffected, and in the course of a week or two the plants are as bad as ever. A dilute mixture is preferable to a strong one for the reason that it spreads more readily over every part of the plant, and some care should be taken to wet the entire plant. The mites are generally most numerous on the lower side of the leaves, and particular pains should be taken in applying the material to these parts. It is generally supposed that the peculiar "frozen" appearance of Golden Wedding and other varieties is due to the ravages of these insects, but this is a mistake. The trouble with those varieties is of an altogether different nature, and one that is said to be caused by a fungus, which may be exterminated by a liberal use of Bordeaux mixture.

Red Spider—Like the preceding, the red spider, *Tetranychus telarius* of scientists, is so small that it has often done serious injury before it is noticed. In a dry atmosphere it forms a regular maze of web-work on the under side of the leaves of the plants, and, if unchecked, in time extends over every part of the entire collection. The treatment is to keep the plants and houses damp.

Tarnished Plant Bug (*Lygus pratensis*)—Among chrysanthem-

mum growers this pest is perhaps better known as the chrysanthemum-fly. This insect is very common, and we are indebted to it for the injury known as "blind growths" or "blind buds." It is of stout build, about one-fourth of an inch in length, and of brownish or yellowish color. It attacks a great variety of plants, both ornamentals and fruit plants, and seems especially fond of chrysanthemums. Anyone who has collected seeds of our hardy herbaceous perennials in autumn must have come in contact with it, for it abounds in the flower heads of asters, solidagos and the like. It punctures the young growths, buds and leaves of chrysanthemums, extracting and subsisting on their juices, and thus renders them useless. Pyrethrum powder and kerosene emulsion are the best preparations for destroying the pest, but where the insects are few in number they may be collected by hand with little trouble.

Thrips—Several species of these little insects infest garden plants. It is known that they injure the foliage by mutilation and by withdrawing its fluids, and their black deposits have the effect of putting a decided stop to the development of the leaves. When the dark, roundish spots are noticed, both surfaces of the leaves of plants out of doors should be thoroughly sprayed with tobacco water, and plants in similar circumstances under glass should be fumigated with tobacco.

A Recent Bud Trouble—A new source of annoyance has appeared within the past year in the form of the premature death of the flower buds. The stem immediately beneath the bud swells to some extent, and this is followed by the gradual decay of the bud and a small portion of the stem, as in Fig. 53. At first it was thought that the trouble was confined to the variety Challenge; but later reports prove this to be erroneous, many of the prominent varieties being affected in the same way, and we have had the variety Red Robin attacked while Challenge grown in the same house remained unharmed. It has been said that mites are the cause



of the malady, and again it is attributed to a fungus, while others look for a bacterial origin. It is more probably due to external mechanical injury caused by some insect much larger than the mites, or in disbudding. In any case it would be well to take the precaution of allowing the buds to attain to good dimensions previous to disbudding.

SUMMARY.

Popular interest in chrysanthemums in America dates from the distribution and extensive advertising of the variety Mrs. Alpheus Hardy in 1888-89.

Varieties for commercial purposes should have dwarf stems (from three to four feet high), strong and erect, furnished with luxuriant foliage to the base of the flowers, which should be large (from four to eight inches in diameter), double, and of a distinct shade of color.

For the purpose of American growers, the American varieties are in general far superior to those of foreign origin.

New varieties should be submitted to the Chrysanthemum Society of America, or its representatives, before being placed on the market. Growers should support the society in its efforts to prevent the increase of synonyms.

Among the new varieties of last year the best for commercial purposes at our place were Eugene Dailedouze and Major Bonnaillon, yellow; Mayflower and Marie Louise, white; Mrs. E. G. Hill and Laredo, pink; and Chas. Davis and Ingomar, bronze.

The best flowers are obtained by bench culture, although good marketable blooms are more cheaply raised on solid beds.

Some study should be given to the insects which infest the plants, so that the helpful ones may be readily distinguished from those of injurious character. The leading injurious ones are black aphids, green-fly, mites and thrips.

The plants are kept free from insect pests by using either pyrethrum powder, kerosene emulsion or tobacco, the last to be applied in the powder form or in frequent light fumigation.

As the premature decay of the flower buds is probably due to external injury, greater care should be exercised in disbudding, allowing the buds to attain to a good size before commencing the operation.

MICHAEL BARKER.

THE TESTING OF VARIETIES.

In answer to inquiries respecting our attitude towards the testing of varieties, I append the following statements of the methods which the Horticultural Division of the Cornell Experiment Station has uniformly pursued. We refuse to test varieties simply because they are new. Our basis of study is the monograph,—the investigation of a particular subject, rather than the indiscriminate growing of things which chance to be put upon the market in a given year, and which have no relationship to each other aside from a coincidence in date. When we take up a certain group of plants for study, we endeavor to secure every variety of it, old or new. These varieties are studied not only in the field, but botanical specimens are invariably made of every one, so that the experimenter has specimens before him for liesurely study when the hurry of field work and the excitement of bug-catching are done. We are always glad to receive the seed novelties of any year, but we do not agree to report upon them or even to grow them. If we were to attempt to grow them all, we should simply be making a museum of curiosities, and we should have no time left for investigation and experiment. More than this, we have to admit that we are incompetent to make a test of all novelties. An opinion of a novelty is of no value unless the person who gives it is well acquainted with all or at least most of the other varieties of the plant, and we find it is impossible to know all garden plants. There are many kinds of fruits and vegetables with which we have only a passing acquaintance, and it would be presumptuous for us to affect a critical knowledge of any variety of them, simply because it happened to be introduced in any given year.

Seedsmen and others, therefore, must not expect reports upon the novelties which they send us, unless the varieties happen to be of plants to which we are giving explicit study. Roots and trees which are sent us are always planted as a part of our collection, and they are given the same attention as other parts of our plantation; but we do not agree to test them for publication, although we are always glad to make a written statement of their behavior.

L. H. BAILEY.

U 50711
N7
C 841-
Bulletin 92.

May 1895 SEP 21

Cornell University Agricultural Experiment Station



AGRICULTURAL DIVISION.

On the Effect of

Feeding Fat to Cows

By HENRY H. WING.

PUBLISHED BY THE UNIVERSITY.

ITHACA, N. Y.

1895.

ORGANIZATION.

BOARD OF CONTROL:

THE TRUSTEES OF THE UNIVERSITY.

STATION COUNCIL.

President, JACOB GOULD SCHURMAN.

Hon. A. D. WHITE,	-	-	-	-	Trustee of the University.
Professor I. P. ROBERTS,	-	-	-	-	President State Agricultural Society.
Professor I. P. ROBERTS,	-	-	-	-	Agriculture.
Professor G. C. CALDWELL,	-	-	-	-	Chemistry.
Professor JAMES LAW,	-	-	-	-	Veterinary Science
Professor A. N. PRENTISS,	-	-	-	-	Botany.
Professor J. H. COMSTOCK,	-	-	-	-	Entomology.
Professor L. H. BAILEY,	-	-	-	-	Horticulture.
Professor H. H. WING,	-	-	-	-	Dairy Husbandry.
Professor G. F. ATKINSON,	-	-	-	-	Cryptogamic Botany

OFFICERS OF THE STATION.

I. P. ROBERTS,	-	-	-	-	Director.
E. L. WILLIAMS,	-	-	-	-	Treasurer.
H. W. SMITH,	-	-	-	-	Clerk.

ASSISTANTS.

M. V. SLINGERLAND,	-	-	-	-	Entomology.
GEO. C. WATSON,	-	-	-	-	Agriculture.
G. W. CAVANAUGH,	-	-	-	-	Chemistry
E. G. LODGMAN,	-	-	-	-	Horticulture.
MICHAEL BARKER,	-	-	-	-	Horticulture.

Office of the Director, 20 Morrill Hall.

Those desiring this Bulletin sent to friends will please send us the names of the parties.

BULLETINS OF 1895.

84. The Recent Apple Failures in western New York.
85. Whey Butter.
86. Spraying of Orchards.
87. The Dwarf Lima Beans.
88. Early Lamb Raising.
89. Feeding Pigs.
90. The China Asters.
91. Recent Chrysanthemums.
92. Feeding Fat to Cows.

ON THE EFFECT OF FEEDING FAT TO COWS.

It is the common opinion of dairymen that the food exerts a great influence upon the quality of the milk, although experiments have long since shown that, in most cases, the quality of the milk is dependent upon the individuality of the cow and is very little affected by the food. The first experiments leading to these conclusions were made in Germany, but several of the American Experiment Stations have experimented along the same lines and in general have confirmed the results of the foreign experimenters.

These experiments, for the most part, have been made to show the influence of rations relatively rich or poor in nitrogen upon the quality of the milk. Comparatively few experiments have been made to show the influence of rations relatively rich or poor in fat upon the milk. This is no doubt due to the fact that it has long been conceded that the nitrogenous part of the ration is the source of a large part, if not all, of the fat in the milk. There have, however, been some experiments made upon feeding foods rich in fat. The most important of those made in this country were made by Wood of the New Hampshire Agricultural Experiment Station,¹ in which cotton seed oil, palm oil, cocoanut oil, oleo oil and stearin were added to a ration composed of hay and ensilage and a grain ration of eight pounds of equal parts of ground oats and middlings. The oils were fed in turn to three different cows in periods of two weeks each. Daily analyses of the milk were made and the conclusions arrived at were as follows:

“That the first effect of an increase of fat in the cow's ration was to increase the per cent. of fat in the milk.

“That with the continuance of such a ration, the tendency was for the milk to return to its normal condition.

“That the increase in fat is not due to the oils, but to the unnatural character of the ration.

¹New Hampshire Agricultural Experiment Station, Bulletin No. 20.

"That the results of feeding oils tend to confirm the conclusions that the composition of a cow's milk is determined by the individuality of the cow, and that although an unusual food may disturb for a time the composition of the milk, its effect is not continuous."

Juretschke has found ² as a result of the addition of 4 to 5 pounds per thousand pounds live weight, of cotton seed cake, rape cake, and peanut cake to a basal ration consisting of hay, straw, brewers grains and wheat bran, that the "milk secretion is not directly but only indirectly affected by the feeding, and that the feeding of large amounts of fat does not increase the amount of butter fat, in the milk."

Spier³ concludes as follows, as the result of feeding cows on pasturage, brewers grains and potatoes with bean meal, cotton seed cake, barley meal and linseed cake, that "although the quantity of milk is easily influenced up to a certain point by the food supply, the quality is not materially altered by any ordinary mixed food.

"The proportion of butter fat is very little influenced by foods containing a large percentage of oil, such as linseed or cotton cake, nor yet by albuminous food, such as bean or pea meal, decorticated cotton cake, etc."

On the other hand, some experiments made by Mr. Henry Van Dreser, of Cobleskill, N. Y., and reported in *Hoard's Dairyman*, Vol. XXV., No. 18, p. 288, June 22, 1894, have shown a remarkable increase in the yield of fat by the addition of tallow to the ordinary ration.

In brief, Mr. Van Dreser's methods and results were as follows:

The cows, thoroughbred Holsteins, had been receiving a ration of 30 pounds of ensilage per day with hay at noon, with a grain ration of six pounds of a mixture of two parts of wheat bran, and one part each of cotton-seed meal and corn meal. The skim milk was also fed back to the cows. At the beginning, one-quarter of a pound per cow per day of clean beef tallow was shaved up and mixed with the grain ration. The cows ate the tallow readily,

² *Molkerei Zeitung*, Vol. VII, 38, p. 518.

³ *Transactions of Highland and Agricultural Society of Scotland*, 1894, p. 83.

and in the course of two weeks the amount was increased to two pounds per day. At the end of five weeks, a week's butter test was made of each cow, the results being as follows :

No. of cow.	Weight.	Butter in one week before feeding tallow.	Butter in one week after feeding tallow.	Gain per cent. by feeding tallow.
1	1189	14. lbs.	20. lbs.	43
2	1130	12. "	17.5 "	46
3	1168	8.5 "	16.875 "	98
4	1000	13.06 "	17.66 "	30

The results of this experiment were so striking and so contrary to the results of similar experiments made previously that it seemed to be worth while to carry the investigation a little further.

On September 14, 1894, five cows of different ages and at different periods of lactation were selected from the University herd for an experiment in feeding tallow. The cows were as follows :

Emma, $1\frac{1}{8}$ Holstein, 4 years old, in milk 4 months and 10 days.

Freddie, $\frac{3}{4}$ Holstein, 9 years old, in milk 15 days.

Garnet Valentine, 73,783 A. J. C. C. H. R., 3 years old, in milk 15 days.

Pearl, $\frac{7}{8}$ Holstein, 6 years old, in milk 25 days.

Pet, $\frac{7}{8}$ Holstein, 9 years old, in milk 5 months.

The cows were at pasture and were receiving a grain ration of 8 pounds per day of an equal mixture of wheat bran and cotton seed meal. This, they continued to receive. During the first week from September 14th to 21st no change was made in the ration. The fat was determined in each milking separately by the Babcock test. At the conclusion of the first week 4 ounces of tallow per day were added to the grain ration night and morning. The cows ate the tallow readily and as fast as seemed best the amount of tallow was increased, 4 ounces at a time, until all of the cows were eating two pounds each per day. This occurred during the 4th week with all of the cows except Pet who seemed to be less fond of the tallow than the others, and did not eat the full ration until the 5th week. The experiment was then continued until the end of the 10th week, when the tallow was discontinued and the milk weighed and fat determinations made for two weeks longer.

For the first six weeks after beginning to feed the tallow, separate determinations of the fat were made for each cow for each

TABLE I—LOT I. GRAIN FOOD AND TALLOW CONSUMED.

Week	Emma.			Freddie.			Garnet Valentine.			Pearl.			Pet.		
	Grain Lbs.	Tallow low. Oz.	Tallow per day. Lbs. Oz.	Grain Lbs.	Tallow low. Oz.	Tallow per day. Lbs. Oz.	Grain Lbs.	Tallow low. Oz.	Tallow per day. Lbs. Oz.	Grain Lbs.	Tallow low. Oz.	Tallow per day. Lbs. Oz.	Grain Lbs.	Tallow low. Oz.	Tallow per day. Lbs. Oz.
Before, Sept. 14-21	56			56			56			56			56		
1st " 21-25	56	48	6 $\frac{6}{7}$	48	42		56	48	6 $\frac{6}{7}$	56	48	6 $\frac{6}{7}$	48	24	3 $\frac{3}{4}$
2d " 28-Oct. 5	56	94	13 $\frac{3}{7}$	56	94	13 $\frac{3}{7}$	56	94	13 $\frac{3}{7}$	56	94	13 $\frac{3}{7}$	52	64	9 $\frac{1}{2}$
3d Oct. 5-12	56	138	1	56	138	1	56	138	1	56	138	1	52	104	14 $\frac{6}{7}$
4th " 12-19	56	204	1	56	204	1	52	190	1	56	204	1	52	144	1
5th " 19-26	56	224	2	56	224	2	52	208	1	56	224	2	51	200	1
6th " 26 Nov. 2	56	224	2	56	224	2	56	224	2	56	224	2	56	224	2
7th Nov. 2-9	56	224	2	56	224	2	52	208	1	56	224	2	56	224	2
8th " 9-16	56	224	2	56	224	2	56	224	2	56	224	2	56	224	2
9th " 16-23	56	224	2	56	224	2	56	224	2	56	224	2	56	224	2
10th " 23-30	56	224	2	56	224	2	56	224	2	56	224	2	56	224	2
After, 1st Nov. 30															
Dec. 7	56			56			56			56			56		
After, 2d Dec. 7-14	56			56			56			56			56		

milking. From the 7th week on, samples were taken from each milking for each cow separately, and a composite test of the same made each week. In the table above is shown the amount of grain and tallow consumed each week by each cow.

It will be seen that the tallow was regularly consumed in full amount by nearly all of the cows. The only exceptions were that Garnet Valentine refused one feed in the 5th week and one in the 7th week.

As the season advanced and the pastures began to fail the cows were fed dry corn stalks and on November 6th, during the 7th week they began to be fed corn ensilage of good quality, carrying a fair crop of ears, and mixed clover and timothy hay. This date really began the period of winter feeding.

No visible effect was noticeable in the health of the cows at any time during the experiment from the effect of feeding tallow, and weights made on November 1st and December 3d showed that the cows had practically neither gained nor lost in weight. The yield in milk and fat is shown in table II.

It will be seen that in general there was no effect in either the yield of milk or percentage of fat that could be traced to the feeding of the tallow. During the first two or three weeks the percentage of fat rose slightly with several of the animals, notably Garnet Valentine and Pet, but toward the close of the experiment the percentage of fat fell slightly with some of the animals, notably Emma and Freddie. There was a constant downward tendency in the yield of milk with all the animals, due undoubtedly to the advancing season and the change from pasture to winter feed.

After the experiment had continued for 3 or 4 weeks and it was seen that no very marked changes in the quality of the milk were taking place it was decided to select another lot of cows for further experiment. There were in the herd, several two-year-old heifers that had recently calved. They were quite thin in flesh and giving small amounts of milk of not very good quality. Several of these heifers were selected for the second lot, the idea being that perhaps they would be more susceptible to radical changes in the food. The second lot of five was selected on October 19th, consisting of the following :

Clara, grade Jersey, 2 years, 9 months old, in milk 10 days.

TABLE II—LOT I—YIELD OF MILK AND FAT (BY WEEKS).

Week.	Emma.			Freddie.			Garnet Valentine.			Pearl.			Pet.		
	Yield of milk. Lbs.	Aver. age per ct. fat.	Yield of fat. Lbs.	Yield of milk. Lbs.	Aver. age per ct. fat.	Yield of fat. Lbs.	Yield of milk. Lbs.	Aver. age per ct. fat.	Yield of fat. Lbs.	Yield of milk. Lbs.	Aver. age per ct. fat.	Yield of fat. Lbs.	Yield of milk. Lbs.	Aver. age per ct. fat.	Yield of fat. Lbs.
Before....	212	3.49	7.398	330.5	3.52	11.629	181.5	4.41	8.008	256	3.11	7.953	251.25	3.63	9.110
1st.....	204.75	3.40	6.970	342.25	3.46	11.838	191.25	4.72	9.018	251	3.16	7.939	257.75	3.48	8.982
2d.....	196.25	3.65	7.158	346.5	3.47	12.037	183.75	4.77	8.759	247.75	3.29	8.161	265.25	3.66	9.717
3d.....	186.75	3.27	6.116	323	3.6	11.633	172.25	4.85	8.351	223.5	3.51	7.842	239.75	3.86	9.266
4th.....	190	3.45	6.551	306.25	3.65	11.172	165.25	5.02	8.300	251.75	3.59	9.042	249.25	4.11	10.248
5th.....	176.5	2.87	5.059	323.5	3.24	10.483	152.25	4.77	7.258	256	3.29	8.428	232.5	3.73	8.676
6th.....	179.25	2.95	5.301	298.75	3.55	10.560	148.5	4.85	7.206	217.5	3.35	7.305	203.25	4.05	8.188
7th.....	174.5	2.95	5.148	303	3.35	10.151	141.75	5	7.088	214.5	3.25	6.971	161.5	4	6.460
8th.....	163.5	2.5	4.088	309	3	9.270	164	4.7	7.708	235.25	3.15	7.410	196.75	3.5	6.886
9th.....	152.75	3	4.583	290.5	3.3	9.587	158	4.55	7.189	229.5	3.25	7.459	207.25	3.85	7.979
10th.....	146.25	2.75	4.022	257.25	2.95	7.589	138.5	4.5	6.233	221	3.25	7.183	174.5	3.6	6.282
After 1st.	147.5	2.7	3.983	298.5	3.1	9.254	153.25	4.15	6.360	233.25	3.15	7.347	184.5	3.25	5.996
" 2d..	126.5	3.25	4.111	288.25	3.3	9.512	148.75	4.25	6.322	199.25	3	5.978	183	3.5	6.405

TABLE III.—LOT II—GRAIN FOOD AND TALLOW CONSUMED.

Week.	Clara.			Dora.			Gazelle.			May 2d.			Nora.		
	Grain Lbs.	Tal- low. Ozs.	Tallow per day. Lbs. Ozs.	Grain Lbs.	Tal- low. Ozs.	Tallow per day. Lbs. Ozs.	Grain Lbs.	Tal- low. Ozs.	Tallow per day. Lbs. Ozs.	Grain Lbs.	Tal- low. Ozs.	Tallow per day. Lbs. Ozs.	Grain Lbs.	Tal- low. Ozs.	Tallow per day. Lbs. Ozs.
Before, Oct. 19-26	56			56			56			56			56		
1st Oct. 26-Nov. 2	56	50	7½	56	50	7½	56	50	7½	56	50	7½	52	42	6
2d Nov. 2-9	56	104	14½	56	104	14½	56	104	14½	56	104	14½	36	58	8½
3d " 9-16	56	176	1 9½	56	176	1 9½	56	176	1 9½	56	176	1 9½	56	176	1 9½
4th " 16-23	56	224	2	56	224	2	56	224	2	56	224	2	56	224	2
5th " 23-30	56	188	1 10½	56	224	2	56	188	1 10½	56	224	2	56	224	2
6th Nov. 30-Dec. 7	56	224	2	56	224	2	56	224	2	56	224	2	56	224	2
7th Dec. 7-14	56	224	2	56	224	2	56	224	2	56	224	2	56	216	1 14½
8th " 14-21	56	224	2	56	224	2	56	224	2	56	224	2	56	224	2
9th " 21-28	56	224	2	56	224	2	56	224	2	56	224	2	56	224	2
10th Dec. 28-Jan. 4	56	224	2	56	224	2	56	224	2	56	224	2	56	224	2
After, 1st Jan. 4-11	56			56			56			56			56		
" 2d Jan. 11-18	56			56			56			56			56		

Dora, $\frac{1}{18}$ Holstein, 3 years, 2 months old, in milk 1 month and 20 days.

Gazelle, grade Jersey, 6 years and 9 months old, in milk one month.

May 2d, $\frac{7}{8}$ Holstein, 1 year and 11 months old, in milk one month.

Nora, $\frac{7}{8}$ Holstein, 2 years 1 month old, in milk 20 days.

The details of the experiment with the second lot were in all respects the same as with the first, except, that they were on the winter feed for a greater part of the time and that the grain fed to the second lot was composed of 8 pounds of a mixture of one fourth bran and three fourths gluten meal by weight, and in the feeding we were able to get the cows upon the full feed of two pounds of tallow each per day in the 3d week instead of the 4th. The amount of feed consumed is shown in table III. No difficulty was found in getting the animals to eat the tallow. The health of all of the animals remained good and no appreciable change in live weight took place.

It will be seen that the tallow was readily and regularly eaten by nearly all of the animals. The exceptions were that Clara and Gazelle only ate a pound and a half per day during the greater part of the 5th week, and Nora refused a part of two feeds in the 7th week. The yield in milk and fat of lot II is shown in table IV.

It will be seen, that as with lot I, there were no variations in the percentage of fat that could be ascribed to the effect of the tallow. At least, there was no increase. The greatest change in percentage of fat was seen in the gradual decrease in the two two-year-old Holstein heifers, May 2d and Nora. There were fluctuations in the percentage of fat in the cows in both lots, but they were intermittent and not progressive.

The time of the experiment fell very naturally into four divisions or periods :

First, the period of one week before beginning to feed the tallow.

Second, the preliminary period of 3 or 4 weeks during which the amount of tallow fed was gradually increasing.

Third, the period of full feeding, 6 or 7 weeks.

Fourth, the final period of two weeks after the tallow was taken away.

TABLE IV—LOT II—YIELD OF MILK AND FAT (BY WEEKS).

Week	Clara.			Dora.			Gazelle.			May ad.			Nora.		
	Yield of milk. Lbs.	Aver. age per ct. fat.	Yield of fat Lbs.	Yield of milk. Lbs.	Aver. age per ct. fat.	Yield of fat Lbs.	Yield of milk. Lbs.	Aver. age per ct. fat.	Yield of fat Lbs.	Yield of milk. Lbs.	Aver. age per ct. fat.	Yield of fat Lbs.	Yield of milk. Lbs.	Aver. age per ct. fat.	Yield of fat Lbs.
Before....	132.25	4.71	6.234	230.5	2.83	6.528	178.5	5.09	9.077	156.	3.03	4.726	179.25	3.64	6.540
1st	120.	5.05	6.039	219.75	3.1	6.822	170.75	5.15	8.803	143.75	3.05	4.381	159.25	4.	6.386
2d	119.5	5.25	6.290	222.5	3.25	7.235	170.5	5.3	9.036	141.25	3.11	4.390	144.5	3.28	4.743
3d	85.5	5.83	4.982	236.5	3.2	7.558	176.5	4.86	8.575	152.	2.85	4.333	167	2.77	4.630
4th	92.	4.64	4.272	194.	2.76	5.357	178.5	5.07	9.053	149.75	2.37	3.555	164.	2.62	4.301
5th	91.75	4.72	4.327	174.75	2.8	4.900	153.75	5.15	7.925	133.	2.34	3.115	149.75	2.59	3.883
6th	91.75	5.02	4.618	213.75	3.14	6.705	156.75	5.34	8.375	145.5	2.62	3.813	139.75	2.98	4.162
7th	95.75	4.5	4.309	217.5	3.2	6.960	148.5	4.75	7.054	144.5	2.45	3.540	140.25	3.15	4.418
8th	106.5	4.2	4.473	224.25	3.2	7.176	155.5	5.	7.775	135.5	2.25	3.049	151.5	2.65	4.015
9th	99.25	4.15	4.119	212.	2.75	5.830	153.25	5.	7.663	132.5	2.25	2.981	152.75	2.55	3.895
10th	88.25	4.7	4.148	190.	2.9	5.510	131.25	5.	6.563	136.25	2.65	3.611	150.	2.65	3.975
After 1st	103.25	4.	4.130	200.75	2.9	5.822	137.5	4.6	6.325	146.	2.7	3.942	160.5	2.55	4.093
" 2d.	101.25	4.8	4.860	218.5	2.95	6.446	136.5	4.7	6.416	152.25	3.15	4.796	172.	3.	5.160

TABLE V—SUMMARY BY PERIODS—LOT I.

Period.	Emma.		Freddie.		Garnet Valen- tine.		Pearl.		Pet.	
	Lbs. milk p'r day.	Aver- age per ct. fat.	Lbs. milk p'r day.	Aver- age per ct. fat.	Lbs. milk p'r day.	Aver- age per ct. fat.	Lbs. milk p'r day.	Aver- age per ct. fat.	Lbs. milk p'r day.	Aver- age per ct. fat.
I. 1 week, before feeding tallow, Sept. 14-21.	30.29	3.49	47.21	3.52	25.93	4.41	36.57	3.11	35.89	3.63
II. 4 weeks, preliminary, amt. of tallow in- creasing, Sept. 21 to Oct. 19.	27.78	3.45	47.07	3.54	25.45	4.83	34.79	3.39	35.56	3.77
III. 6 weeks, on full feed of tallow, Oct. 19 to Nov. 30.	23.64	2.84	42.43	3.24	21.50	4.73	32.71	3.26	26.95	3.79
IV. 2 weeks, after feeding tallow, Nov. 30 to Dec. 14.	19.57	2.95	41.91	3.20	21.57	4.20	30.89	3.08	26.25	3.37
2 mos. afterward, week ending Feb. 14.	20.36	3.1	42.14	3.3	17.82	5	29.07	3.35	8.61	4

SUMMARY BY PERIODS—LOT II.

Period.	Clara.		Dora.		Gazelle.		May ad.		Nora.	
	Lbs. milk p'r day.	Aver- age per ct. fat.	Lbs. milk p'r day.	Aver- age per ct. fat.	Lbs. milk p'r day.	Aver- age per ct. fat.	Lbs. milk p'r day.	Aver- age per ct. fat.	Lbs. milk p'r day.	Aver- age per ct. fat.
I. 1 week, before feeding tallow, Oct. 19-26.	18.89	4.71	32.93	2.83	25.50	5.09	22.29	3.03	25.61	3.64
II. 3 weeks, preliminary, amt. of tallow in- creasing, Oct. 26 to Nov. 16.	15.48	5.33	32.32	3.18	24.65	5.10	20.81	3.00	22.42	3.35
III. 7 weeks, on full feed of tallow, Nov. 16 to Jan. 4.	13.58	4.55	29.10	2.98	21.99	5.05	19.94	2.42	21.38	2.73
IV. 2 weeks, after feeding tallow, Jan. 4-18.	14.60	4.35	29.95	2.93	19.57	4.65	21.30	2.93	23.75	2.78
2 mos. afterward, week ending Mar. 18.	13.68	5.5	33.43	3	17	4.9	19.25	3.05	24.14	3.2

In table V the average yield of milk per day for each cow and the average per cent. of fat for the whole period is grouped together, and to this has been added the average yield of milk per day and percentage of fat two months after the close of the experiment.

In table V it is seen that there is no very marked change in the percentage of fat and yield of milk in the period when the cows were on a full feed of tallow. While there are slight variations in the percentage of fat, they rarely reach one half of one per cent. and what is of more significance they are not uniform. Some of the cows gave richer milk and some poorer on a full feed of tallow than they did before or after.

It is of interest to note the average daily yield of milk and the percentage of fat for each cow two months after the close of the experiment which is included in Table V. It will be seen that all the cows except Pet were still giving practically the same amount of milk of the same quality, and Pet at this time had practically reached the end of her period of lactation.

CONCLUSION.

In this quite extended trial there has been no increase in the fat in the milk by feeding tallow to the cows in addition to a liberal grain ration. These results were obtained with ten different cows, of two breeds of various ages, in various periods of lactation, extending over a period of ten weeks, for at least six of which they ate two pounds per head, per day of tallow.

HENRY H. WING.

**TRADE VALUES OF FERTILIZING INGREDIENTS
IN RAW MATERIALS AND CHEMICALS.
SEASON OF 1895.**

Frequent inquiries lead us to believe that the following information is timely:

	<i>1895. Cents per pound.</i>	<i>1894. Cents per pound.</i>
Nitrogen in ammonia salts.	18½	19
" " nitrates	15	14½
Organic nitrogen in dry and fine ground fish, meat, blood, and in high-grade mixed fertilizers....	16½	18½
" " " cotton-seed meal.....	12	15
" " " fine ground bone and tankage.....	16	16½
" " " fine ground medium bone and tankage.....	14	15
" " " medium bone and tankage.....	11	12
" " " coarse bone and tankage.....	5	7
" " " hair, horn-shavings, and coarse fish scraps	5	7
Phosphoric acid soluble in water	6	6
" " soluble in ammonium citrate	5½	5½
" " in fine bone and tankage.. ..	5½	5½
" " in fine medium bone and tankage.....	4½	4½
" " in medium bone and tankage.....	3	3
" " in coarse bone and tankage.....	2	2
" " in fine ground fish, cotton-seed meal, and wood ashes	5	5
" " insoluble (in am. cit.) in mixed fertilizers...	2	2
Potash as High Grade Sulphate, and in mixtures free from Muriate	5¼	5
" " Muriate	4½	4½
The manurial constituents contained in feedstuffs are valued as follows :		
Organic Nitrogen	15	15
Phosphoric Acid	5	5
Potash.....	5¼	5

In applying the foregoing prices to the guaranteed analysis of a commercial fertilizer it should be remembered that no allowance has been made for mixing the fertilizer, commission or freight to interior points, as the prices given are the average wholesale prices in the larger cities on the Atlantic sea-board for six months previous to March, 1895.

It should be remembered that ammonia is 82.3 per cent. nitrogen ; that sulphate of potash is 54. per cent. actual potash, and muriate (chloride) of potash 63.5 per cent. actual potash.

In buying and applying commercial plant food the following brief rules may be adhered to in the majority of cases :

Chemicals or mixed fertilizers of high grade furnish cheaper plant food than those of a low grade.

Wherever a good crop of clover or other leguminous plants can be grown they will produce nitrogen cheaper than it can be obtained in commercial fertilizers.

Well drained upland soils are usually deficient in nitrogen but not in phosphoric acid.

Reclaimed low lands are frequently deficient in phosphoric acid but contain an abundance of nitrogen.

Muriate of potash should not be applied to sugar beets, tobacco or potatoes.

Fruit trees making a yearly growth of from six inches to one foot do not need nitrogen but are usually benefited by a moderate application of potash and phosphoric acid.

The greater the leaf surface of a plant the more potash it requires.

Nitrogen salts should be applied only in such quantities as meet the requirements of the crop, on account of the liability of loss from leaching.

Nitrates should always be applied on the surface to a growing crop.



630.617

N7
C8eb

SECOND EDITION.

Bulletin 93.

May, 1897



Cornell University Agricultural Experiment Station,

ENTOMOLOGICAL DIVISION.

The Cigar-Case-Bearer

In Western New York.



By M. V. SLINGERLAND.

PUBLISHED BY THE UNIVERSITY

ITHACA, N. Y.

1897

ORGANIZATION.

BOARD OF CONTROL: THE TRUSTEES OF THE UNIVERSITY.

STATION COUNCIL.

President, JACOB GOULD SCHURMAN.

Hon. A. D. WHITE,	-	-	-	-	-	Trustee of the University.
Professor I. P. ROBERTS,	-	-	-	-	-	President State Agricultural Society.
Professor I. P. ROBERTS,	-	-	-	-	-	Agriculture.
Professor G. C. CALDWELL,	-	-	-	-	-	Chemistry.
Professor JAMES LAW,	-	-	-	-	-	Veterinary Science.
Professor A. N. PRENTISS,	-	-	-	-	-	Botany.
Professor J. H. COMSTOCK,	-	-	-	-	-	Entomology.
Professor L. H. BAILEY,	-	-	-	-	-	Horticulture.
Professor H. H. WING,	-	-	-	-	-	Dairy Husbandry.
Professor G. F. ATKINSON,	-	-	-	-	-	Cryptogamic Botany.

OFFICERS OF THE STATION.

I. P. ROBERTS,	-	-	-	-	-	-	Director.
E. L. WILLIAMS,	-	-	-	-	-	-	Treasurer.
H. W. SMITH,	-	-	-	-	-	-	Clerk.

ASSISTANTS

M. V. SLINGERLAND,	-	-	-	-	-	Entomology.
GEO. C. WATSON,	-	-	-	-	-	Agriculture.
G. W. CAVANAUGH,	-	-	-	-	-	Chemistry.
E. G. LODEMAN,	-	-	-	-	-	Horticulture
MICHAEL BARKER,	-	-	-	-	-	Horticulture

Office of the Director, 20 Morrill Hall.

Those desiring this Bulletin sent to friends will please send us the names of the parties.

BULLETINS OF 1895.

84. The Recent Apple Failures in western New York.
85. Whey Butter.
86. Spraying of Orchards.
87. The Dwarf Lima Beans.
88. Early Lamb Raising.
89. Feeding Pigs.
90. The China Asters.
91. Recent Chrysanthemums.
92. Feeding Fat to Cows.
93. The Cigar-Case-Bearer.

CORNELL UNIVERSITY, ITHACA, N. Y., April 18, 1895.

THE HONORABLE COMMISSIONER OF AGRICULTURE, ALBANY.

Sir: One of the serious insect pests which we met when prosecuting our investigations of the apple orchards of western New York last year, is the Cigar-Case-Bearer. A brief sketch of this insect was given in Bulletin 84, and the present paper is the account which was promised in that bulletin. Mr. Slingerland has made a very careful study of the insect, and this account of it is approved by Professor Comstock. This case-bearer will probably take its place along with other staple pests which, by harrying the apple-grower, will hasten the study and improvement of our orchard interests; and this bulletin is therefore recommended for publication under Chapter 230 of the Laws of 1895, as an important contribution to the advancement of apple cultivation.

L. H. BAILEY.

BIBLIOGRAPHY.

1889. Lintner. Fifth Report, p. 324. Received specimens from Rochester, N. Y., at work on young pears, June 8, 1888. (As *Coleophora* sp.)
1890. Lintner. Popular Gardening, v, 198. Brief account of its work on young pears; early arsenical spray advised. (As *Coleophora* sp.)
1891. Lintner. Sixth Report, p. 347. Same as 1890 account above.
1892. Fletcher. Report for 1891, p. 196-198. Good account of habits and spraying experiments. (As *Coleophora* sp.)
- . Fletcher. Evidence before Com. of House of Commons, p. 9. Brief account of habits and experiments against. (As *Coleophora* sp.)
- . Fernald. Canadian Entomologist, xxiv, 122. Original description of moth; case also described. (As *Coleophora fletcherella*.)
1893. Fletcher. Report for 1892, p. 4. Brief mention.
- . Lintner. Ninth Report, p. 374. Brief mention.
1894. Fletcher. Twenty-fifth Report of Ont. Ent. Soc., p. 79-80. Best account of life history and remedies.
- . Fletcher. Evidence before Com. of House of Commons, p. 19. Brief account.
1895. Fletcher. Report for 1894, p. 201-206. Habits and life history; remedies.

THE CIGAR-CASE-BEARER.

Coleophora fletcherella Fernald.

Order LEPIDOPTERA ; superfamily TINEINA.

During the past year (1894) fruit trees in western New York have suffered severely from the attacks of two, practically new, insect pests. One of these, the plum-scale, was discussed in Bulletin 83 ;



and in the following pages are given the results of our investigation of the other insect, the cigar-case-bearer.

Judging from the number of inquiries, with their accom-

panying specimens, that reached the insectary in 1894, this case-bearer was one of the most serious pests of the season. Professor



54.—Work of the cigar-case-bearer on apple foliage, June 14. (From Bailey.)

Bailey's observations, recorded in Bulletin 84, p. 15, also show that the insect was very destructive, especially in the apple orchards in Wayne and Monroe counties. Figure 54 is a fair sample of its destructive work on apple foliage; many of the smaller leaves are dead, and others are almost entirely skeletonized by the insect. We have no definite data as to just how much damage the insect did in 1894. Apparently it now ranks next to the bud-moth (Bulletin 50) in destructiveness; and the two insects are often seen at work on the same branches.

Thus this new case-bearer affords an additional emphasis to the fact that eternal vigilance on the part of the fruit grower is now the price which must be paid for the finest and best fruit.

ITS PAST HISTORY AND DISTRIBUTION.

Doubtless this case-bearer has been present in limited numbers in New York orchards for many years; and it may have been previously noticed by some fruit growers, but it was not until 1888 that public attention was called to it, by Mr. P. Barry, of Rochester, N. Y. He found it boring holes in newly-set pear fruits, and specimens were sent to Dr. Lintner; these specimens furnished the text for the first published account of the insect, by Dr. Lintner in 1890. In 1892, Dr. Lintner received some apples from Oswego, N. Y., which had apparently been bored by this case-bearer.

Nothing further seems to have been heard of the insect in our State until last year (1894). Then specimens began to come into the insectary from western New York as early as February, and continued coming in increased numbers during the months of May and June. Specimens were received from the following localities: Rochester, West Brighton, Moreton Farm, North Rose, Albion, Newark, Sodus and South Byron; this winter we have also received specimens from North Parma, and have seen the insect here at Ithaca. The specimens sent in indicated that it was present in alarming numbers in nearly every case. Doubtless it will be found generally distributed throughout the State, and it probably also occurs in neighboring States.

The insect is also very numerous in Canada. It first attracted attention there in 1889 at Charlottetown, Prince Edward's Island. In 1891, it appeared in alarming numbers at Adolphustown, On-

tario; and a few were also found at Port Williams, Nova Scotia. Last year it did very serious damage in several localities in Ontario; specimens were also sent to the insectary from Lakeville, Nova Scotia.

Thus, this case-bearer has so far been recorded only from New York and Canada, and has appeared in alarming numbers only in western New York and Ontario. Attention was first directed to the insect at about the same time in the widely separated localities of Rochester, N. Y. and Prince Edward's Island. It was especially destructive in Ontario in 1891 and in both New York and Ontario in 1894; and judging from specimens received this winter, hundreds of the little creatures are passing through their long winter's fast safely and will be ready to satisfy their hunger on the opening buds of thousands of fruit trees in western New York in the spring.

ITS APPEARANCE.

On account of its small size and peculiar habits the insect itself, in any stage, will rarely be noticed by the fruit grower. But one of the curious suits, or cases as they are called, which the little caterpillar wears is quite conspicuous, thus often revealing its presence to even the casual observer.

The caterpillar and its curious case.—The caterpillars are their own tailors and each has two suits during its lifetime. The first suit or case is made in the fall when the caterpillar is about two or three months old; it is worn all winter and until about May 15th of the next spring. As this case is quite small, it is often overlooked by the fruit grower. This phase of the insect's life is discussed in detail further on under the account of its life history.

About May 15th, the half-grown caterpillar finds that its winter suit is too small and proceeds to make a new and larger summer case; we caught the little tailor at this work one morning and a photograph of the interesting process is presented further on, with an account of the operation. This second case presents a striking resemblance to a miniature cigar, both in its shape and color. In May or June, one or more of these curious cigar-shaped cases may often be seen projecting at various angles from a leaf (Figure 55) or from a young fruit (frontispiece); and as the figures show, they are quite conspicuous objects. They are sure to

arouse one's curiosity, especially when, after watching one for a few minutes, it is seen to move off to another part of the leaf.



55.—Cigar-case-bearers at work ; natural size.

A careful examination of one of these moving, cigar-like objects will reveal its inhabitant, a dark orange-colored, black-headed caterpillar scarcely one-fifth of an inch in length. When disturbed, the little creature retreats into its cigar-shaped case and can be induced to come forth only by either tearing open its case, or by continued urging from the rear. As described in detail further on in discussing its life history, the insect passes the remainder of its life until the emergence of the adult in this cigar-shaped case.

The adult insect.—The moth, shown nearly four times natural size in figure 56, is a very delicate and pretty steel-grey object. During the day it rests on a leaf with its heavily fringed wings folded closely over its abdomen and its long slender antennae placed close together and projecting straight forward from its head. They may be seen on the leaves from about June 15th to July 15th.



56.—*Adult insect, about four times natural size.*

INDICATIONS OF THE PRESENCE OF THE INSECT.

The first indications of the presence of this case-bearer appear on the swelling buds of apple, pear, or plum trees. Early in the spring of 1894, we saw hundreds of them at work on pear buds near Rochester, N. Y.; they were then in their small curved cases (figure 59), and were quite conspicuous as they projected from the surface of the swelling buds. Two or three often occurred on a single bud busily at work eating minute round holes, scarcely larger than a pin, into the buds. The buds open quite rapidly, and as many of the caterpillars do not awaken from their winter's sleep thus early in the season, the damage done on the opening buds is small compared with their later work on the foliage.

The work of the insect on the expanded foliage takes the form of various sized, skeletonized, dead, and brown areas which have near their centers a clean-cut small round hole through one skin (usually the one on the underside) of the leaf. These skeletonized areas are well shown in figure 57. When the insect is very numerous, often so much of the inner tissue of the leaf is thus eaten out that the whole leaf turns brown and dies. Several of the leaves on the branch shown in figure 54 were killed in this way, and several of the others almost entirely skeletonized. Thus the work of the case-bearer on the foliage is quite conspicuous, and may be easily recognized with the aid of the figures.

The caterpillars also often attack the forming fruit. In fact, the insect first attracted public attention by its work on the fruit of pears; Dr. Lintner has also found their work on apples. The frontispiece well illustrates their work on the fruit. The cater-

pillar eats a circular hole through the skin and then revels in the flesh beneath, sometimes eating as far as it can reach and not let



57.—Characteristic work of the caterpillars on the leaves ;
natural size.

go of its case. Our observations indicate that after the fruit attains about twice the size of the one shown in the frontispiece, it is but little injured by the attacks of this case-bearer.* But, as Mr. Fletcher states, the insect also attacks the stems of the flowers and setting fruit, and often does much damage in this way. Figure 58 shows a young pear which was killed by the case-bearer attached to it ; we re-

ceived this specimen from Albion, N. Y., on May 29th, 1894.

Thus the presence of this case-bearer may be indicated, not only by its peculiar appearance, but by its eating minute holes in the swelling buds, by its skeletonizing irregular areas on the leaves, by its attacking the stems of the flowers and setting fruit, or by the destruction of the young fruit itself.

ITS NAME.

The striking resemblance of the larger case, which the caterpillar carries about with it, to a miniature cigar, suggested to Mr. Fletcher the apt popular name of cigar-case-bearer for this insect.

It belongs to the large group of minute moths



58.—A cigar-case-bearer attached to a young pear which it had killed ; natural size.

* Several larvae were placed under a net on pears on a tree near the insectary ; and although they punctured the fruit in several places, in every case

known as Tineids ; nearly all of the Tineids are easily distinguished from other moths by their narrow wings, which are bordered with very wide fringes (Fig. 56). When Dr. Lintner first saw this case-bearer in 1888, he referred it to the Tineid genus *Coleophora*. It was not until 1892, however, that it received a specific name. Then Dr. Fernald named it *fletcherella*, in honor of Mr. Fletcher, who gave us the first extended account of its habits and life history. Thus, the insect is scientifically known as *Coleophora fletcherella*.

ITS LIFE HISTORY.

This little case-bearer is one of the most interesting insects, as regards its life-history and habits that it has been our pleasure to study. It has been under almost daily observation here at the insectary from the time it awakes from its winter's sleep until it passes through its wonderful transformations into the delicate little moth, from whose beautifully sculptured eggs the little caterpillars hatch ; and these soon demonstrate that they are both miners and tailors. We have also been fortunate enough to secure pictures of some of the most interesting phases of its life ; no illustrations of the insect or its work have heretofore been published.

Hibernation.—By September 15th most of the little creatures have gone into winter quarters as minute, half-grown, orange-yellow caterpillars encased in a small curved suit, and firmly attached to the bark, usually



59.—The small curved cases in which the caterpillars hibernate on the twigs ; the upper part of the figure is natural size, while the two lower twigs are twice natural size.

the scar healed and was scarcely visible on the mature fruit. It is doubtful if this case-bearer has anything to do with the hard knotty kernels which are so often accompanied by irregular pustular spots or cracks ; this mysterious affection which was so prevalent on the fruit in many pear orchards in western New York in 1894, may be the work of plant-bugs or of the plum curculio.

on the smaller branches. In figure 59 are shown many of the insects in hibernation; the upper part of the figure shows the cases natural size, while the two lower twigs are about twice natural size. The large case so conspicuous on the right hand twig is one of the cigar-shaped cases fastened there during the summer by a mature caterpillar; it serves well to contrast the two suits worn by the caterpillars during their lifetime. Where the insect is numerous, they may be quite easily discovered in their winter quarters; the specimens figured were recently sent in by a correspondent at North Parma, N. Y.

Nearly seven months of the insect's life is spent in idleness in these snug, curved cases on the twigs of the trees.

Appearance and habits in the spring.—The little caterpillars awake from their long winter's fast early in the spring, as soon as the buds begin to open. In 1894, the little cases were loosened from the twigs about April 15th, and the march of the hungry caterpillars for the buds began; on April 25th we saw hundreds of them on pear buds near Rochester. Their manner of work-



60.—The winter cases, with their spring additions; much enlarged.

ing on the buds has been described on page 219.

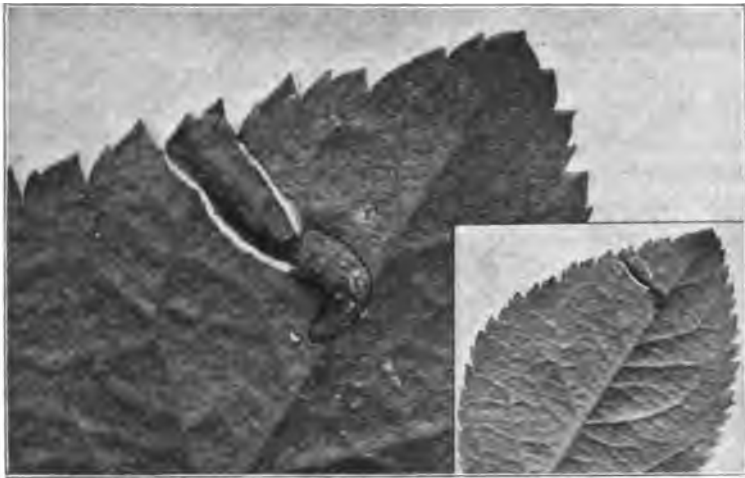
As the caterpillars continue feeding on the expanding foliage, they soon find that their winter suits or cases are too short for their growing bodies; and they proceed to build on extensions at one end. In figure 60 are shown, considerably magnified, two of these enlarged spring suits or cases; from one, the head of the caterpillar projects. The smoother portions of the cases in the figure represent the winter suit. The portions added in the spring are much rougher, apparently consisting of bits of the fuzzy skin of the young leaves glued together; in many cases this added portion is nearly as long as the original winter case.

However, the little caterpillars increase in size so fast in the spring, that by the middle of May most of them find their spring

suits entirely inadequate for their wants. Then their tailoring instinct again asserts itself and they proceed to construct their second and last suit or case.

The construction of its cigar-shaped suit or case.—In the construction of this, its summer suit, the caterpillar illustrates in a very interesting manner the instinctive powers of insects. We were fortunate enough to catch one of the little tailors at work on its new suit, and the camera has faithfully reproduced what we saw (Fig. 61).

During the forenoon of May 31st, we found one caterpillar that was still in its spring suit or case. It was transferred to a fresh



61.—*The little tailor at work making its summer cigar-shaped suit; much enlarged, except the leaf in the corner, which is natural size.*

leaf, where it at once traveled to a point on the underside a short distance from the edge. There work was begun by first eating a small round hole through the skin of the leaf; it then began feeding upon the inner tissue between the two skins of the leaf. By nightfall it had thus eaten out the tissue over a narrow elongate area reaching to the edge of the leaf. The little tailor must have continued its work nearly all night, for at eight the next morning what we saw is represented, considerably enlarged in figure 61; the leaf in the lower right-hand corner is natural size. The caterpillar had mined out the inner tissue over the narrow

area, for the purpose of using the two skins of the leaf remaining above and below the mined area, as the cloth out of which to make its new suit. As the figure shows, the little tailor had then adroitly cut out his suit by cutting through both skins along the sides of the mine, leaving a few strands uncut to act as guy ropes to hold the skins in position while they were being neatly joined together by the silken threads spun by the caterpillar inside. The stocking shaped object shown on the leaf in the figure is the caterpillar's discarded spring suit. When the photographs for figure 61 were taken, the caterpillar was busily at work spinning a smooth silken lining in its new suit. At this stage of the proceedings, it became a martyr to science and the whole leaf now forms an interesting addition to our collection illustrating the different phases of this curious case-bearer.

When first sewn together, the two skins of the leaf make a flattened case. This is gradually constricted into the more rounded cigar-shape, doubtless by the caterpillar in tightening his silken lining inside. The round hole eaten through the skin of the leaf when the mine is begun, now serves as the entrance to the new case. When the case is complete, the caterpillar in some manner manages to break the now dry and brittle guy ropes, and elevating its new suit in the air walks off to seek new pastures, leaving the little empty case attached to the leaf. These cigar-shaped cases, being thus formed from bits of the upper and lower skins of a leaf, show, under a lens, on one side the characteristic raised veinlets of the upper skin and on the other the fine hairs of the lower skin. Usually the side seams form slight ridges on the case.

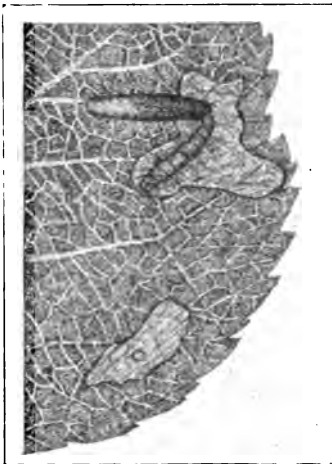
Our wonder at the ingenious tailoring which the little caterpillar did in our cage was increased, when, upon further examination of many infested leaves sent in by correspondents, we found that most of them had shown still more ingenuity in their work. Many of the leaves received May 31st had had their basal edges eaten away in a peculiar manner; and the explanation was always at hand in the form of one of the little curved cases, always empty, attached at the point where the leaf joins its stem. In figure 62 are shown three such leaves natural size; quite often both basal edges would be cut away, as shown in the figure. Why should the caterpillars always seek this particular portion

of the leaf from which to make their cases? Mr. Stainton tells us it is for the simple reason that the little tailor saves itself much trouble by thus mining at the edge of leaf, because the upper and lower skins are already joined together along one side, the edge of the leaf, and the making of one seam is thereby avoided.*



At the upper end, these cigar-shaped cases are contracted rather abruptly into a three-lipped, star-shaped orifice, the lips of which fit closely together. This orifice,

or back door, is used for a special purpose by the caterpillar, as we shall see later.



Its habits as a cigar-case-bearer.—Most of the caterpillars finished their cigar-shaped summer suits by May 25th, in 1894. After this date, they feed mostly on the leaves, and do their most damaging work during the next three weeks. The peculiar manner in which they feed is well shown in figure 63. A small hole is eaten through one skin of the leaf and the soft inner tissue

is then mined out. The caterpillar protrudes itself from its case and feeds as far as it can reach in several directions, thus forming an irregular blotch-mine. The little miner never lets go of its case while at work, and quickly wriggles back into it when disturbed. Many of these blotch-

* Natural History of the Tineina, by H. T. Stainton. Vol. iv. Coleophora, part I, p. 8. (1859.)

mines with their entrance holes are shown in figure 57. The caterpillar keeps the interior of its home neat and clean by using the small hole in the upper end of the case as a back door out of which all of the excrement is ejected.

Some of the caterpillars become full grown by June 4th, but most of them continue feeding until about June 20th. They then seek a suitable place, usually on the leaves but sometimes on the branches, where they securely fasten their case with silk, in nearly the same position in which the caterpillar holds it while feeding. So securely are they fastened that they remain in place long after they are of any further use to the insect; this fact accounts for the cigar-shaped cases sometimes found among the small curved hibernating cases on the branches in winter, as shown on the right-hand branches in figure 59.

Pupation.—If one of these cigar-shaped cases be cut open about ten days after it was fastened as described above, there will be found inside, not the dark orange-colored caterpillar, but a light brown quiescent object, known as the pupa. Thus these cigar-shaped cases serve both as a summer suit for the caterpillar and as a secure cocoon within which the insect undergoes its transformation to the adult stage.

After fastening its case, and before changing to a pupa, the caterpillar in some manner turns around in its case, for the head end of the pupa is always found nearest the upper end of the case.

Emergence of the moth, and egg laying.—About ten days after the change to a pupa takes place in the cigar-shaped cases, there emerges through the lipped orifice in the upper end of the case a minute steel grey moth—the adult insect (Fig. 56). In our cages, some of the moths emerged as early as June 25th, but others did not appear until July 15th.

The moths remain at rest on the leaves during the day. They doubtless feed but little, if any, and do no damage. Some of the moths that emerged June 25th had laid eggs three days later. In our cages, most of the eggs were snugly tucked away among the numerous hairs on the undersides of the youngest leaves near the mid ribs; some were similarly laid on the young, hairy branches. They are apparently not glued to the hairs, as they are easily dislodged.

The eggs are of a delicate light lemon-yellow color, and quite

deeply pitted over their entire surface with triangular depressions separated by narrow ridges (Fig. 64). They are cylindrical in shape with rounded ends, and measure .31 by .25 mm., thus being scarcely visible to the unaided eye. Under a lens they are beautiful objects. The egg stage lasts about two weeks, the little caterpillars emerging about July 15th.



64.—The egg ;
greatly mag-
nified.

Mining habits of the recently hatched caterpillars.—The newly-born caterpillars are miners, and at once eat through one skin of the leaf and begin a mine in the soft inner tissue. They keep their mines clean as they go, by throwing all of their excrement out of the entrance hole. They continued to feed in this manner for about two weeks, or until August 3d, in our cages ; then, owing to our inability to keep their food fresh any longer, they died.

Construction of their winter suit or case, and the fall migration of the caterpillars.—After feeding as miners for two or three weeks, the young caterpillars exercise their tailoring instincts by constructing tiny curved cases in which they are to pass the winter. One of Mr. Fletcher's correspondents saw many of these little cases on the leaves on August 10th. We have not been able to catch the little tailor at its work of making its winter suit ; but Mr. Fletcher says they cut clean holes through the leaves by taking oval pieces from the upper and lower skins of the leaves with which they form their curious cases by joining them together along their edges. Doubtless the process is similar to the one used in making the summer cigar-shaped cases as shown in figure 61. These small curved cases (Fig. 59) also have an opening in the upper end out of which the caterpillars eject their excrement.

Probably they feed for several days on the leaves after they make these curved cases. About September 1st, migration begins from the leaves to the twigs, where they securely fasten their cases, which then serve as snug, warm, and secure quarters for the winter. Many of these hibernating case-bearers are shown in figure 59.

Briefly summarized, the life history of this case-bearer is as follows : The insect spends about seven months (from September 15th to April 15th) of its life in hibernation as a minute half grown caterpillar in a small case attached to a twig (Fig. 59).

In the spring, the caterpillars attack the opening buds, the expanding leaves, the stems of the flowers and fruit, and the forming fruit (Figs. 55 and 58). By May 20th, its hibernating case with its spring additions (Fig. 60) is discarded for another and larger cigar-shaped case (frontispiece and Fig. 58) which the caterpillars deftly makes from pieces of the upper and lower skins of the leaves (Fig. 61). Protruding themselves from these cases, they eat through one skin of the leaf and mine out the inner tissues over an irregular area, as far as they can reach and not let go of their case (Fig. 63). In the latter part of June, they cease feeding, securely fasten the cases to the leaves or branches, and change to pupae within. The moth (Fig. 56) emerges in about three weeks, and soon lays minute, pretty, yellow, pitted eggs (Fig. 64) among the hairs on the young leaves. The egg stage lasts about two weeks, the little caterpillars emerging about July 15th. They work as miners in the tissues of the leaf for two or three weeks, then abandon their mining habit and construct their curious little curved cases from bits of the skins of the leaves. By September 15th, they have all migrated to the twigs, where they pass the winter in these cases (Fig. 59.)

NATURAL ENEMIES.

We have not met with any natural enemies of this case-bearer, but in 1891, Mr. Fletcher bred a few minute hymenopterous (Chalcid) parasites from the cases in Canada.

HOW TO COMBAT IT.

It is practicable to fight this case-bearer in its caterpillar stage only; and it is then so well protected in its case as to render its destruction dependent upon very thorough work.

Extensive experiments in Canada by Dr. Young, of Adolphustown, Ont., have demonstrated that there is but little hope of reaching the caterpillars while they are in their winter quarters on the twigs. Dr. Young sprayed his trees in the winter with kerosene emulsion, using it both cold and warm (probably diluting it with nine parts of water), and failed to destroy the caterpillars in their little cases. Perhaps a stronger emulsion might have been more effective, but it is very doubtful if any spray will

reach the insect in its winter quarters. Thus the only time when it can be effectually reached is when it is actively feeding in the spring.

We have had no opportunity of carrying on any experiments against the insect ; but we advised all of our correspondents in 1894 to spray thoroughly in the early part of June with Paris Green, one pound to 200 gallons (always using two or three pounds of lime to prevent injury to the foliage from free arsenic). Several reported very satisfactory results. The first spraying should be made as soon as the little cases are seen moving in the spring, that is, about the time the buds begin to open. Repeat the application from four to seven days later, for the leaves open fast and soon present much unpoisoned surface for the case-bearers to work upon. In Canada, Dr. Young has had very good results from the Paris Green thus applied.

Fortunately, this is just the time when the bud-moth (discussed in Bulletin 50) can be the most successfully combated with the same spray. In fact, the cigar-case-bearer and the bud-moth often worked on the same leaves in many western New York orchards in 1894. The Paris Green may be effectually combined with the Bordeaux Mixture at this time for the first application for the apple scab fungus.

While Dr. Young found the Paris Green spray very effective, as mentioned above, he also discovered that a spray of kerosene emulsion, diluted with nine parts of water,* applied thoroughly in the spring when the caterpillars are active, was still more effective. Some of our correspondents have also thought they

* To make the Emulsion, thoroughly dissolve one-half pound hard or soft soap in one gallon boiling water. While this solution is still very hot add two gallons of kerosene and quickly begin to agitate the whole mass through a syringe or force-pump, drawing the liquid into the pump and forcing it back into the dish. Continue this for five minutes or until the whole mass assumes a creamy color and consistency which will adhere to the sides of the vessel, and not glide off like oil. It may now be readily diluted with cold rain water, or the whole mass may be allowed to cool when it has a semi-solid form, not unlike loppered milk. This standard emulsion if covered and placed in a cool dark place will keep for a long time. In making a dilution from this cold emulsion, it is necessary to dissolve the amount required in three or four parts of boiling water, after which cold rain water may be added in the required quantities.

checked the bud-moth with the emulsion used at this time for other insects. It is also a fortunate coincidence that the same emulsion spray, when directed against the case-bearer in pear orchards, will also be just in time to catch the recently-hatched nymphs of that dreaded pest, the pear-psylla, discussed in Bulletin 44.

To summarize, we believe that this cigar-case-bearer can be kept in check by two or three thorough sprayings with Paris Green, one pound to 200 gallons of water. The first application, which may be effectually combined with the Bordeaux Mixture then to be used for the apple scab fungus, should be made as soon as the little cases are seen on the opening buds. A second, and perhaps a third, application may be necessary at intervals of four to seven days on badly infested trees. These sprayings will also check the bud-moth.

Furthermore, it has been experimentally demonstrated in Canada that a kerosene emulsion spray, applied at the same time as directed above for Paris Green, still more effectively checks the case-bearer; and we believe it would act likewise on the bud-moth. In peach orchards, both this case-bearer and the pear-psylla can be effectually checked by the same emulsion spray when the leaves are opening in the spring. Never spray a fruit tree when it is in blossom.

Remember that success in any case will depend almost entirely on how thoroughly the spraying is done.

MARK VERNON SLINGERLAND.

U 501011
N7
C8eb



Bulletin 94.

May, 1895.

Cornell University Agricultural Experiment Station.
BOTANICAL DIVISION.

DAMPING OFF.



By GEO. F. ATKINSON.

PUBLISHED BY THE UNIVERSITY,
ITHACA, N. Y.
1895.

ORGANIZATION.

BOARD OF CONTROL:

THE TRUSTEES OF THE UNIVERSITY.

STATION COUNCIL.

President, JACOB GOULD SCHURMAN.

Hon. A. D. WHITE,	-	-	-	-	Trustee of the University.
Professor I. P. ROBERTS,	-	-	-	-	President State Agricultural Society.
Professor I. P. ROBERTS,	-	-	-	-	Agriculture.
Professor G. C. CALDWELL,	-	-	-	-	Chemistry.
Professor JAMES LAW,	-	-	-	-	Veterinary Science.
Professor A. N. PRENTISS,	-	-	-	-	Botany.
Professor J. H. COMSTOCK,	-	-	-	-	Entomology.
Professor L. H. BAILEY,	-	-	-	-	Horticulture.
Professor H. H. WING,	-	-	-	-	Dairy Husbandry.
Professor G. F. ATKINSON,	-	-	-	-	Cryptogamic Botany.

OFFICERS OF THE STATION.

I. P. ROBERTS,	-	-	-	-	Director.
E. L. WILLIAMS,	-	-	-	-	Treasurer.
H. W. SMITH,	-	-	-	-	Clerk.

ASSISTANTS.

M. V. SLINGERLAND,	-	-	-	-	Entomology.
GEO. C. WATSON,	-	-	-	-	Agriculture.
G. W. CAVANAUGH,	-	-	-	-	Chemistry.
E. G. LODEMAN,	-	-	-	-	Horticulture.
MICHAEL BARKER,	-	-	-	-	Horticulture.

Office of the Director, 20 Morrill Hall.

Those desiring this Bulletin sent to friends will please send us the names of the parties.

BULLETINS OF 1895.

84. The Recent Apple Failures in western New York.
85. Whey Butter.
86. Spraying of Orchards.
87. The Dwarf Lima Beans.
88. Early Lamb Raising.
89. Feeding Pigs.
90. The China Asters.
91. Recent Chrysanthemums.
92. Feeding Fat to Cows.
93. The Cigar Case-Bearer.
94. Damping Off.

The potting bed fungus, Artotrogus debaryanus (Hesse).

Damping of prothallia, Artotrogus intermedius (deBary).

Note on the genus Artotrogus.

A potting bed fungus new to America, Completozia complens Lohde.

A new cutting bed fungus, Volutella leucotricha Atkinson.

Canker in cucumbers.

Damping off by a sterile fungus.

DAMPING OFF.

"Damping off" is a disease of seedling plants which rots or disintegrates the tissues at the surface of the ground. The tissues thus changed weaken, lose their firmness and supporting power, and the seedling falls prostrate on the soil. The disease is wide spread and sometimes very common. It occurs not only in gardens and fields but is a very frequent attendant upon the culture of seedling plants in the forcing house or bed. The trouble is favored by damp soil, comparatively high temperatures, and humid atmosphere.

The term "damping off" is therefore indicative of one of the attendant conditions of the soil inducing the disease. While this popular expression is thus far significant of the trouble it is by no means the exact statement of the case. The plants do not damp off because of the abundant damp or moisture in the soil. The dampness encourages the growth of minute parasitic plants, not visible to the unaided eye, which pierce the seedling, feed upon its substance and set up disintegration processes which result in the death and collapse of the affected parts. Soon after the plant falls the dissolution of the tissues near the surface of the ground has usually proceeded so far that communication by the ordinary physiological processes of life is cut off, and the plant then withers and dies. While damping off is due to the action of minute fungus parasites, it is by no means caused by one and the same

Frontispiece. This is from a photograph of an experiment to show the parasitic nature of the *Artotrogus debaryanus* (Hesse). Before planting the cucumber seed the pots were filled with soil which was thoroughly wetted and then steamed in the steam sterilizer for several hours on three successive days in order to kill all the organisms. The seed was then planted and when just coming up some plant tissue with freshly developed stages of the fungus was placed by the seedlings in pots 5, 6, and 8, while pot 7 was left as a check. The result can be easily seen in the photograph, the check plants remaining unharmed while all the plants in 6 are killed and only one remains healthy in each of 5 and 8.

species. Different species of fungi may under some conditions produce nearly or quite identical phenomena in the progress and culmination of the disease. Some species develop phenomena allied to genuine cases of damping off, and the final result of which is practically the same, the decay of the stem near the surface of the ground and the collapse of the seedling.

Some variations in the external appearance furnish diagnostic characters correlated with the presence of certain species of the parasite, but it is doubtful if in any case the specific cause should be confidently asserted without recourse to microscopic examination, sometimes to be preceded by special treatment. In discussing the several species of fungi which have been found to contribute a share in the production of the disease it will be convenient to take up first the species to which the trouble is generally attributed, and then to follow with others which play a more or less important part in the development of similar or nearly identical troubles.

THE POTTING BED FUNGUS.

*Artotrogus debaryanus*¹ (Hesse).

This fungus is responsible for a large part of the damping off of young seedlings. It is very widely distributed, being very common in the soil of gardens and also in the forcing house. It is common also in many fields, but it probably is more abundant in soil where numbers of plants are grown from the seed in a more or less crowded condition, especially those plants which are known to be predisposed to its attacks. It has however been found in virgin soil taken freshly from the woods into the forcing house."

It is thus a very common and unwelcome bed-fellow and pot-companion of many seedling plants which are more or less crowded

¹ *Pythium debaryanum* Hesse. The name *Pythium* was used in 1823 as a generic name for two species (*Mucor spinosus* Schrank, and *M. imperceptibilis* Schrank, Denkschr. d. k. acad. d. wiss. z. Munschen, 1813, 14) by Nees von Esenbeck Nova acta acad. Leop. XI, 2,515, which belong to another genus (*Achlya*, see Fischer, Rabenhorst's Krypt. Flora. IV, 332). *Artotrogus* (Montagne, Sylloge, 304, 1845) was the next name which was used for a member of this group and must consequently take the place of *Pythium* Pringsheim, Jahrb. wiss. Bot. II, 303, 1860.

² Humphrey, 8th Ann. Rept. Mass. St. Agr. Exp. Station, 221, 1860.

in the seed bed or forcing pots of our gardens and hot houses, especially if undue moisture is present in the soil. In the gardens it is frequently impossible to control the amount of moisture in the soil, and in the forcing house where often the light is defective, the air is not fresh or it is supercharged with moisture, it is often nearly or quite impossible by the ordinary methods to preserve that equilibrium of environment which will permit the growth of the seedling and at the same time check the growth of its inimical guest.

All experienced gardeners are probably familiar with the appearance of the diseased seedling when affected with the damping off fungus. At this day when the germ theory of disease, both animal and plant, has so completely poisoned the minds of all classes of people there is little difficulty in successfully advocating what is now an established fact, that the damping off fungus is a parasite in the seedlings and invades the tissue of the latter for the purpose of obtaining its food. It is fortunate therefore that especial attention can be given to setting forth the facts in the structure and development, and other peculiarities of the parasite, which are quite important to know in order to properly treat it, and also because it can then be distinguished from others either near or remotely related, some of which induce diseases in the early life of certain ferns or fern-like plants and cannot disease seedlings.

The first striking peculiarity in a bed or pot of seedlings affected with the disease which attracts our attention is the prostrate condition of a few plants while others are upright and apparently healthy. The prostrate plants are found to be shrunken at or near the crown, i. e. near the root or the surface of the ground. Frequently when our attention is thus first called to the disease the collapsed tissue of some of the prostrate plants is so far disintegrated as to be in a soft and rotted condition, so that on pulling at the plant it breaks easily at this point. Farther investigation will show that usually the entire root system is by this time decayed, while the greater part of the stem above ground and the young leaves are still green and possibly quite fresh, or flabby, or more or less wilted.

The conditions of the aerial portions of the plant at this early stage of its fall are largely dependent upon the moisture content of the atmosphere. If the moisture be quite dry the seedling will be quite flabby before it falls and will soon wilt thereafter, but if the moisture content is large the tissue will remain quite firm for a time unless the soil upon which it is lying is so saturated with moisture as to encourage the rapid growth of the fungus in the prostrate portion of the plant. When this is the case the entire plant soon becomes a putrid mass and the tissues often take on a dark color.

After attention has been called to the trouble by the preliminary collapse of a few plants, if others are carefully noted some will probably present a paler green color than the perfectly healthy ones, especially near the surface of the ground. If such plants are carefully examined they will probably show the presence of the fungus in the tissues of the root and lower part of the stem, for the fungus requires several hours after entering the tissues to produce such changes which would be visible to the unaided eye.

Mycelium. If from one of these prostrate plants a portion of the collapsed part of the stem is teased apart on a glass slip, such as is used in microscopic work, in a little water and then examined under the microscope the vegetative phase of the parasite will probably be apparent. It exists as slender, colorless, thread-like irregular tubes, which appear to be more or less tangled in the tissues of the seedling. These tubes are the *hyphae*, as they are called, of the fungus, and collectively make up the *mycelium*. The hyphae are branched in quite a profuse manner, the successive branches usually forming somewhat more slender hyphae than the parent ones, so that the main hypha is frequently larger than the branches.

The hyphae course between and through the cells. Where a hypha passes through a cell wall it is very much constricted or very much more slender than it is in the cell lumen of the seedling or between the cells. The hypha in boring its way through these walls excretes a ferment, it is supposed, which dissolves the cellulose of the walls at the point of contact. A quite minute opening in the wall is sufficient for the growing end of the hypha to squeeze its way through and maintain communication with the

older portion, and has the advantage of requiring a much less expenditure of energy than if the opening were made of the same size as the hypha. After passing through the cell wall the hypha enlarges to the normal size.

While the mycelium is comparatively young the inner portion of the hypha is continuous, i. e., there are no cross walls partitioning the tubes into sections. This is a characteristic possessed by a very large group of fungi to which the *Arlotrogus* belongs, known as the *Phycomycetes*. The protoplasm within the hypha is finely granular when the mycelium is young, but in the larger threads as they become older the granules become coarser, their contents are not so homogeneous, and the granules tend to collect into groups or very irregular masses, somewhat resembling the protoplasm in some mucors.

In a crowded seed bed after a few plants have fallen, unless the disease is checked, it will spread from these affected ones as centers to others near them and thus from the one or several starting points the plants will fall until nearly or quite all of them have been killed. Where the soil and atmosphere is quite damp and the temperature conditions so high as to favor rapid growth of the fungus it will grow out from the diseased part of the stem into or on the surface of the soil for a few millimeters in extent as a very delicate cottony mass or velvety pile. Where the adjacent plants are not too far distant the superficial threads may thus reach them and communicate the disease to them. In other cases minute motile reproductive bodies called *zoospores*, or *swarm spores* (perhaps more properly *zoogonidia*) are developed in a manner to be described later. These swim in the soil water to the more distant seedlings and thus spread the disease.

Sometimes there will be seen quite a profuse growth of a mycelium, which on the surface of the soil may spread several centimeters in extent. Usually this profuse growth is that of another fungus, a *Rhizopus*, or *Mucor*, or in other cases a different "damping off" fungus to be described in a later paragraph.

If the tissues examined as described above from a seedling which has not remained long after falling over perhaps the condition of the mycelium described will be the only phase of the plant (for the fungus is a plant) at that time present. If it has

been dead for sometime, however, there will probably be seen here and there on the hyphae a number of rounded or spherical bodies, three to five times the diameter of threads of the mycelium with which they are connected. These are reproductive organs of the fungus and will soon be described.

The characters of the mycelium alone are not in all cases sufficient for the correct determination of the plant. Let then this preparation on the glass slip lie free in an abundance of water, and place the slip in a small moist chamber sufficiently protected so that the air in the chamber will not become dry by evaporation at the point of contact of the two vessels. This can be avoided by placing a sheet of wet filter paper between the cover and the edges of the bottom vessel. A Petrie dish, such as is used in bacteriological work, is excellent for the purpose. Some wet filter paper should also be placed in the bottom and on this the support for the glass slip can be placed. For hasty examination the material can be teased out directly in the bottom vessel of the Petrie dish in a little water, and then this can be placed on the stage of the microscope whenever it is desired to examine it.

In twelve to twenty-four hours if the preparation is again examined many threads of the fungus will be seen to have grown out from the tissue and spread on all sides for a distance of one to two millimeters in the surrounding water, now presenting the characters noted above in a clear manner, except there are no constrictions of the hyphae corresponding to those where they pass through the cell walls of the host. The branching is in an alternate or irregularly monopodial fashion. There will also be seen numbers of the rounded bodies noted above on the mycelium, both within the tissue and on the mycelium which is growing free in the water around its margin.

Sexual organs. Oogonia. The larger number of these rounded bodies in the case of this species will probably be what are termed oogonia. These are developed in several relations to the hyphae which bear them. They may be terminal, i. e. on the ends of the hyphae which bear them, or on the ends of quite short branches, or intercalary, i. e. when they appear as swellings of the hyphae here and there without any reference to the end.

A terminal oogonium begins as a slight swelling of the rounded

end of a hypha or short branch, which continues until the spherical body is about 18μ – 25μ in diameter. During its growth in size the protoplasm which fills the interior is supplied by the supporting hypha or oogoniophore, without, however, emptying any portion of the latter structure. When the oogonium has reached its full size, a septum, or partition wall, is formed cutting off its protoplasm from that of the stalk or oogoniophore. At this time the wall of the oogonium is thin and the protoplasm finely granular, though distinctly so, and completely fills the interior of the oogonium. The wall now increases somewhat in thickness, but remains colorless.

The egg cell of the oogonium is now soon differentiated, and in most cases, except where parthenogenesis takes place, is probably influenced by the development of the antheridium. The finely granular protoplasm of the oogonium becomes coarser and is gradually collected into numerous small irregularly rounded masses. At the same time all of the coarsely granular protoplasm contracts from the wall of the oogonium and moves toward the center forming there a rounded central mass somewhat less in diameter than that of the oogonium, being 14μ – 18μ in diameter. This central sphere of coarsely granular protoplasm is termed the oosphere, or egg cell, and is really an unfertilized egg, the receptive cell of the oogonium. Between this egg cell and the wall of the oogonium is a space filled with a nearly clear, but finely granular and homogeneous fluid called the periplasm. At this stage there is no wall surrounding the egg cell and it is ready to be fertilized.

Antheridia.—The sole purpose of the antheridia is to supply the fertilizing element for the egg cell, and the antheridium is sometimes termed the supplying gamete, while the oogonium is termed the receptive gamete. The antheridia are of two kinds, stalk antheridia and branch antheridia. A stalk antheridium is formed from a section of the oogoniophore by the formation of a partition wall in the hypha cutting off an elongated cell one end of which is thus in contact with the wall of the oogonium, and its contents are only separated from those of the oogonium by the wall of the latter. This is the simplest of the two forms of the antheridia.

A branch antheridium is developed as a lateral branch of the oogoniophore, arising usually quite near the oogonium, but sometimes more or less remote from it, rarely on a separate hypha. The branch grows towards the oogonium and its rounded end comes in contact with the oogonium wall and becomes fixed at the point of contact. A septum is now formed in the branch cutting off an elongated cell varying from 15μ – 40μ . This cell, one end of which is in contact with the oogonium wall, is the antheridium, and the proximal portion of the branch is the antheridiophore. More than one antheridium may be formed in connection with a single oogonium, frequently two and sometimes three. Both may be branch antheridia, or one may be a branch antheridium and the other a stalk antheridium, and other combinations may take place where more than two antheridia are present. There does not seem to be any rule in the number of antheridia which take part in the fertilization of the egg cell. Where several are in contact one or more may take part in the act of fertilization.

When the antheridial cell is formed its farther development is the same whether it be a branch antheridium or a stalk antheridium. The cell which is cylindrical or nearly so in form begins to swell and this continues until it is two to three times the original diameter, the greatest diameter being near the end which is in contact with the wall of the oogonium. At the same time it also becomes quite strongly curved and more or less twisted. In case the oogonium is a terminal one and possesses both a stalk antheridium, and branch antheridium, the stalk antheridium may curve so strongly to one side as to make it difficult to determine later which is really the stalk antheridium.

While these changes are taking place in the antheridium the granular protoplasm of the oogonium is moving toward the center to form the egg cell as described above, and now the end of the antheridium in contact with the wall of the oogonium, puts out a slender tube which pierces the oogonium wall, extends across the space occupied by the periplasm and touches the egg cell at the nearest point. This tube is known as the fertilization tube. At this point on the egg cell there is a small clear space called the receptive spot.

Nearly all of the protoplasm in the antheridium except a very

thin layer next the wall becomes coarsely granular, arranged in strings and is finally collected in the middle line of the antheridium. This is known as the gonoplasm, and soon passes through the fertilization tube and is emptied into the egg cell at the receptive spot, where it disappears in the substance of the egg cell and completes the act of fertilization.

While the passage of the gonoplasm is going on it can be seen that a thin wall is forming around the egg cell over the surface except at the point where the fertilization tube is located. When the gonoplasm has passed through, the wall becomes complete at that point, and the entire wall then thickens somewhat and soon becomes brown in color. The fertilized egg cell now becomes the egg, or oospore.

These phenomena in the development of the oogonia and antheridia and in the fertilization of the egg cell can be quite easily followed by teasing out a small section of the diseased plant tissue in water on a cover glass and arranging this for a cell culture in what is known as a van Tiegham cell. This can be placed on the stage of the microscope from time to time and the development traced. From such a culture made from a diseased young melon seedling the following record was made. The diseased tissue was teased out in water on a glass slip Monday, Jan. 28, and placed in a moist chamber. The following day, Jan. 29, a profuse growth of mycelium, oogonia and antheridia had taken place, the mycelium extending for 2mm to 3mm out from the diseased tissue. Jan. 30 a small portion of this tissue was farther teased out and mounted in fresh water in a cell culture. Jan. 31 farther growth had appeared and new oogonia and antheridia were developed. This continued for several days in the same culture.

On Feb. 1 at 12:30 P. M. as shown in fig. 1, the egg cell in the oogonium has formed and the antheridium curved over on one side is full size but the fertilization tube has not yet formed nor has the gonoplasm differentiated, the granular protoplasm being arranged in a network of threads. At 3:15 P. M. of the same day as shown in fig. 2 the fertilization tube is complete, the gonoplasm has formed and is about to pass through the tube, while a very thin wall is forming around the egg cell except at the receptive spot. At 9 P. M., fig. 3, the gonoplasm has passed through and the wall

of the oospore is complete. Fig. 4 represents an intercalary oogonium which was observed in the stage figured, at 12:30 P. M., Feb. 1. Two antheridia are here in contact with the oogonium *s. a.* a stalk antheridium and *b. a.* a branch antheridium. In both cases the fertilization tube is complete, and the gonoplasm has separated preparatory to passing through. The curving of the stalk antheridium has turned the main thread to one side, the branch antheridium arising quite closely by the side of the oogonium has curved inward to the wall of this organ. At 3:30 P. M., fig. 5, the gonoplasm has passed through the fertilization tube from both antheridia and a thin wall has formed around the now fertilized egg. Fig. 6 at 12 P. M., showed a terminal oogonium with two antheridia, one a stalk antheridium and one a branch antheridium, it being difficult in this case to say which is the stalk and which is the branch. An accident happened to this specimen and it was not seen again. Fig. 7 represents two terminal oogonia each with a stalk antheridium, first observed at 9 P. M., Feb. 1. At this time in the case of oogonium *a*, the egg cell is formed, and the gonoplasm in the antheridium has separated, while in oogonium *b*, the egg cell has not yet formed. From the fact that the stalk antheridium was on the under side of oogonium *b*, when it was first observed, the stage of its development could not be seen. At 2 P. M., on Feb. 2, however, fertilization was completed in both as shown in fig. 8. Fig. 9 represents an oogonium with a fertilized egg and two antheridia in contact with its wall; one, *a*, a stalk antheridium whose gonoplasm took part in the act of fertilization, and one, *b*, a branch antheridium from a different hypha from that on which the oogonium is borne. From the latter the gonoplasm was not used.

These oospores or fertilized eggs mark a very important phase in the life history of the fungus. They will eventually germinate and produce the mycelium again, which under favorable conditions will start the disease anew. But the remarkable thing about the oospores is that they cannot germinate immediately, except in rare instances, but must undergo a long period of rest, and hence are sometimes termed resting spores. In this condition they are capable of resisting degrees of cold and dryness which would prove fatal to the vegetative portion of the fungus. This accounts partly

for the appearance of the disease after long periods of drought and after the inclement weather of the winter season in some sections.

Not only does the thicker wall of the oospore offer greater protection against an unfavorable environment, but the protoplasm undergoes a marked change before it finally enters upon this enforced period of rest. This change is practically a metamorphosis, the complete nature of which we do not understand. Among other changes there is probably a change in the molecular or physical structure of the protoplasm by which a large amount of a fatty substance is separated and forms a very large globule and sometimes other smaller ones which occupy a large part of the space of the oospore. The protoplasm thus becomes transformed into a state highly resistant to outside conditions and incapable of growth for a long period, even though the environment may be most favorable for growth. The period of rest lasts for several, four to five, months. They will resist freezing for weeks, followed by drying, without injury.

Propagative organs. Organs of another kind than oogonia and antheridia are developed on the mycelium. The function of these is chiefly for the immediate and rapid propagation of the numbers of the parasite. The organs are, like the oogonia, either terminal or intercalary swellings of the hyphae, and at first do not differ materially from them before the differentiation of the egg cell and antheridium. These organs are exactly alike in form but differ in the discharge of their functions and are termed respectively, conidia, resting conidia, and zoosporangia.

Conidia. The conidia measure about the same as the oogonia and when fresh water is added to them they will germinate immediately after maturity, which is attained upon reaching their full size.

Resting conidia. These are conidia which do not germinate immediately and acquire a somewhat thicker wall than the conidia. They pass through a period of rest before germinating. They are identical in form and size with the conidia. They are capable of growing after being frozen, and after drying, and serve in this way much the same function that the oospores do in that they tide the fungus over quite long periods which are unfavorable for the growth of the plant.

In germination the conidium thrusts out, by an extension of

its wall, at one or more points, a slender tube which elongates into a hypha exactly like those of the former mycelium. This enters a young seedling when favorably situated, and starts the disease again.

The conidia and zoospores are rarely developed so abundantly in this species as are the oogonia. In my cultures during Jan. and Feb. 1894-5 the oogonia were far more abundant and no zoosporangia were observed. DeBary says that sometimes one may search for weeks and even months and not find zoosporangia. I have therefore not had as yet an opportunity of studying the formation of the zoospores from the zoosporangia and cannot say whether or not they agree with those of *Artotrogus intermedius* (deBary), which will be described in the next paragraph. The following account is therefore abbreviated from published descriptions.³ The zoosporangia are usually not to be differentiated from the conidia until the time for the development of the zoospores. They are either terminal or intercalary, and sometimes so much of the protoplasm migrates into them during development from the supporting hypha that this is emptied for a short distance near the point where the wall separates the zoosporangium from the contents of the hypha. They usually remain attached to the supporting hypha and at the time of maturity, if placed in fresh water containing oxygen, a short protuberance is developed on one side at nearly right angles to the supporting hypha, which grows to a very short tube of a varying length but always shorter than the diameter of the zoosporangium. Into this tube the protoplasm migrates and causes the end of the short tube to swell out into a rounded vesicle of about the same diameter as that of the zoosporangium, with a thin enclosing membrane. The protoplasm now breaks up into a number of kidney shaped masses, with two lateral cilia according to most authors, although Hesse⁴ who first described the process in this species says that the zoospores are oval and uniciliate. These swarm about in the water for a few minutes, come to rest, round off and germinate in the ordinary way for conidia by sending out a slender germ tube

³ DeBary, Zur Kennt. d. Peronosporaceen, Bot. Zeit. 39, 521, 1881, Beitr. z. Morph. u. Phys. d. Pilze, IV, 1881.

Schroeter, Pilze, in Engler u. Prantl, Naturl. Pflanzenfam. 1, 104.

⁴ Hesse, *Pythium debaryanum*, ein entophytischer schmarotzer, Halle, 1874.

which when favorably situated will start the disease in fresh plants. It is probably by the development of these in wet soil during rain or at the time of watering the pots or soil in seed beds that the disease is spread so rapidly.

The fungus is however capable of developing as a saprophyte on dead or partially decayed organic matter in the soil so that with one watering it may become well seated in nearly all parts of the bed. To show that it is also a saprophyte it is a very easy matter to start it in the laboratory on the leaves or stems of seedlings which have been previously killed by boiling.

This damping off fungus was first described by Hesse in 1874 (l. c.) and named by him *Pythium debaryanum*. It was shown by him to be a parasite of seedlings, such as *Camelina sativa*, *Trifolium repens*, *Spergula arvensis*, *Panicum miliaceum* and *Zea mays*, while seedlings of *Solanum tuberosum*, *Linum usitatissimum*, *Papaver somniferum*, *Brassica napus*, *Ornithopus sativus*, *Onobrychis*, *Pisum*, *Hordeum vulgare*, *Triticum vulgare* and *Avena sativa* were not attacked.

DeBary made a comprehensive study of the sexual stage.⁵ *Pythium equiseti* Sadebeck, is in his opinion the same species. *P. equiseti* was first described by Sadebeck⁶ in 1874 from prothallia of *Equisetum arvense*, and in farther studies⁷ it was shown that not only did it occur in potatoes affected with *Phytophthora infestans*⁸ but that healthy potatoes could be inoculated with it. *Pythium autumnale* Sadebeck which grew in young plants of *Equisetum palustre* and *E. limosum*, produces oospores which develop parthenogenetically. Fischer⁹ places this in *P. debaryanum*. A plant found in *Lepidium sativum*, and in *Beta* and *Sinapis* by Lohde,¹⁰ was described by him as *Lucidium pythioides* and from

⁵ Beitr. z. Morph. u. Phys. d. Pilze, IV. 1881.

⁶ Ueber einen der familie der Saprolegniaceen angehorigen Pilze in dem prothallien des Ackerschachtelhalmes. Sitzungsab. d. Bot. Ver. d. Prov. Brandenburg, 116-122, 1874.

⁷ Neue Untersuchungen über *Pythium equiseti*. Sitzungsab. d. Gesells. naturf. Freunde z. Berlin, V. 21, 1875.

⁸ Ueber Infectionen welche *Pythium*-Arten bei lebenden Pflanzen hervorbringen. Beibl. z. Tageb. d. 49 Vers. deutscher naturf. u. Aertze. 100, 1876.

⁹ Rabenhorst's Krypt. Flora. Pilze, IV, 404, 1892.

¹⁰ Ueber einige neue parasitische Pilze. Tagebl. d. 47 Vers. deutscher Naturf. u. Aertze, 203, 1874.

the description there is little doubt that it is the *Artotrogus debaryanus*. *L. circumdans* described by the same author in a fern prothallium¹¹ develops only in the margin of the same, producing short conidiophores and zoosporangia with 4-8 zoospores. Fischer¹² also includes this with *P. debaryanum* Hesse, as well as the *Saprolegnia schachtii*¹³ described by Frank in the thallus of the liverwort *Pellia epiphylla*. Zoospores were not seen and oogonia only rarely, the plant being usually sterile.

A number of these are probably rightly referred to *Artotrogus debaryanus* (Hesse). Unfortunately these plants cannot well be preserved for study in their several stages and in most of the cases probably no specimen of any stage has been preserved, so that it would be quite impossible at the present time at least to speak with any feeling of certainty on the proper disposition of these forms. There is need of a thorough and comprehensive study of the species of the genus, and considerable uncertainty will probably exist as to the proper disposition of some of the above species until they can again be found and critically studied.

The fungus has been several times reported in this country, and many notices of damping off have been made without, probably,

¹¹ Ueber einige neue parasitische Pilze. Tagebl. d. 47 Vers. deutscher Naturf. u. Aertze, 203, 1874.

¹² Rabenhorst's Krypt. Flora, Pilze, IV, 404, 1892. 4 Ibid.

¹³ Notes on the fungus causing damping off, etc. Trans. Mass. Hort. Soc. I. 1891.

Explanation of Plate I. *Artotrogus debaryanus* (Hesse).

Figs. 1, 2 and 3, different stages in fertilization; *a* antheridium, *oog.* oogonium, *e. c.* egg cell, *gon.* gonoplasm, *oosp.* oospore.

Figs. 4 and 5 intercalary oogonium with stalk antheridium (*s. a*) and branch antheridium (*b. a.*), in 4 with gonoplasm separated from the periplasm, and in 5 fertilization complete.

Fig. 6 terminal oogonium with stalk and branch antheridium.

Figs. 7 and 8 different stages in development, and fertilization, of sexual organs; *b* in 7, oogonium before the formation of the egg cell.

Fig. 9 oogonium with stalk antheridium (*a*) which has fertilized the egg cell, and branch antheridium (*b*) from another hypha than that which bears the oogonium. In this branch antheridium the gonoplasm has separated, and the fertilization tube has formed, but fertilization took place from the stalk antheridium first and the wall of the oospore prevented the use of the gonoplasm from the branch antheridium.

All the figures drawn with aid of camera lucida and magnified 50 times more than the scale. Scale—1 millimeter.

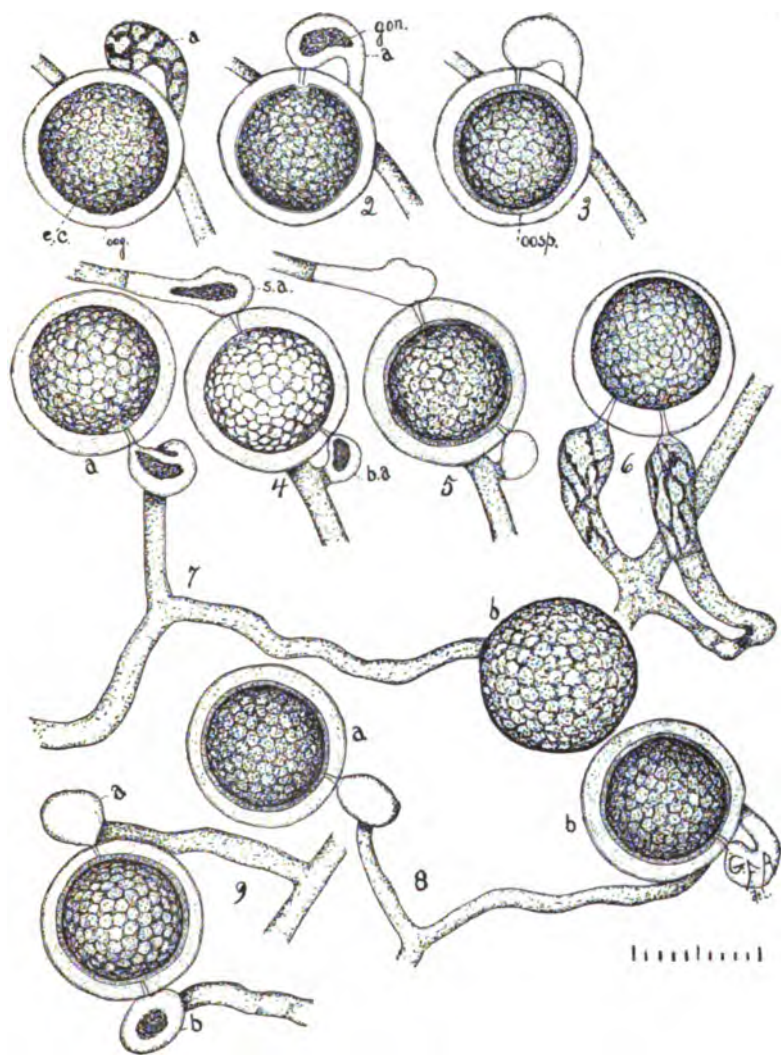


PLATE I.—*Artotrogus debaryanus* (Hesse).

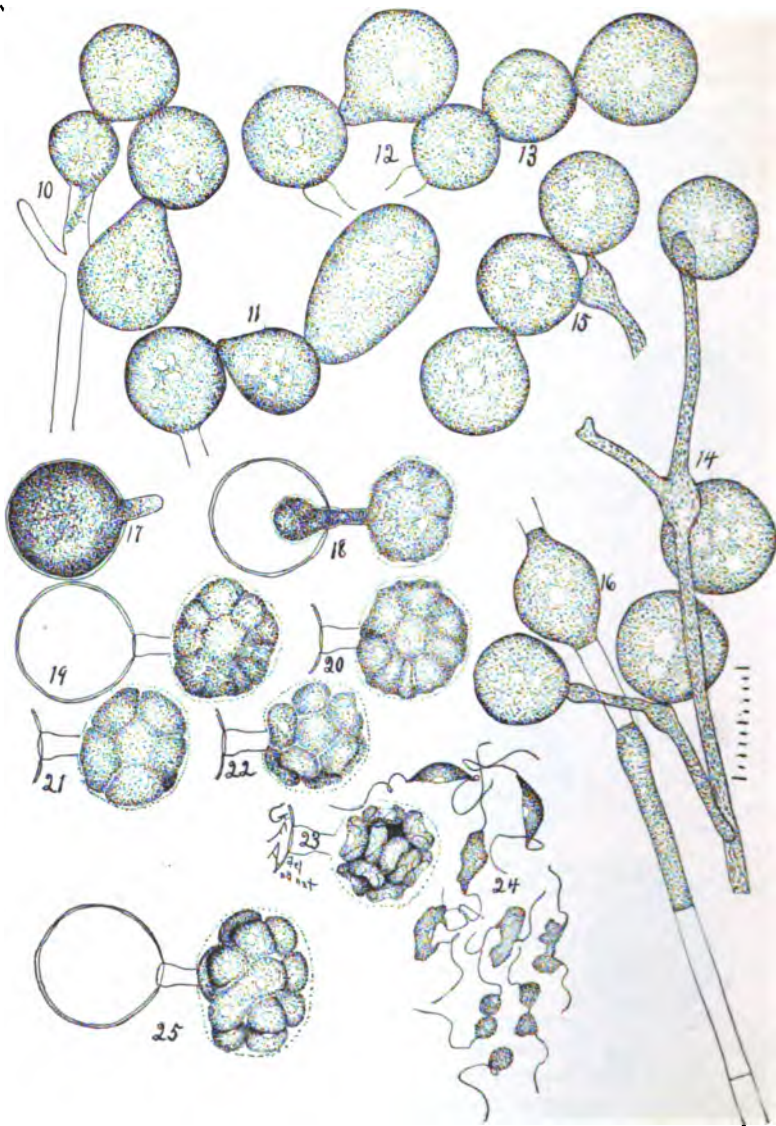


PLATE II.—*Artotrogus intermedius* (de Bary).

any serious attempt to determine the species. T. W. Galloway from a careful study determined it from seedlings of *Gilia*, *Viscaria*, *Lobelia*, etc., in the Botanic Garden of Harvard University. He did not however observe the zoospores. Humphey¹⁴ also carefully determined the species, but does not describe the zoospores.

DAMPING OF PROTHALLIA.

Artotrogus intermedius (deBary).

This species was first noticed in fern prothallia growing in the botanical conservatories of Cornell University in the month of February, 1894. The affected prothallia were quite soft, limp, and darker in color than the healthy ones. Some were placed in water on a glass slip and kept in a moist chamber. The following day the fungus had grown out of the prothallial tissue and had extended a considerable distance over the slip. The mycelium is at first non setate and contains granular protoplasm which is present in minute irregular masses, having in the larger threads much the appearance of the protoplasm in some mucors, and in some cases well marked and strong currents of the protoplasm have been observed, which resemble the movement of the protoplasm in these plants.

The threads branch monopodially, the extent of the branching depending, to a certain extent on the amount of the vegetive growth. The threads put out in the water from the prothallia may be quite long and possess primary and secondary branches before conidia are developed to any great extent. The conidia are developed at the ends of the main threads or their branches, the hypha swelling at the end into a rounded body several times the

¹⁴ 8th Ann. Rept. Mass. State Agr. Exp. Station, 220, 1890.

Explanation of Plate II. *Artotrogus intermedius* (deBary).

Figs. 10, 11, 12, 13, conidia developed in chains.

Figs. 14 and 15, conidia borne in a manner resembling the conidial fructification in *Phytophthora*.

Figs. 17-23, different stages in the development of the zoospores.

Fig. 24, free zoospores with a cilium at each pointed end, passing into amoeboid movement and becoming divided into oval unciliated zoospores.

Fig. 16, intercalary conidium.

All the figures from camera lucida drawings and magnified 50 times more than the scale. Scale 1 millimeter.

diameter of the thread itself. In other cases the thread may develop a conidium while it is still quite short and the growth of the thread in length practically cease. In other cases the conidia are developed at the ends of the primary or secondary branches as well as at the end of the main hypha. Where the conditions are not favorable for the rapid growth of the vegetative portion of the plant, sometimes the conidia are developed more profusely and rapidly so that they are many times produced in chains. Frequently these are in nearly straight chains, or they may form a curve, or again a short and close spiral so that they are held close to the point of origin in a small head.

The conidium may be spherical or broadly apiculate at the proximal end or more minutely apiculate at the distal end. Sometimes there is no enlargement of the fruiting thread at the point of origin of the conidium, but very frequently, and in a majority of cases which I have observed where they are grown in water, there is an oval enlargement of the hypha with a minute apical sterigma which bears the conidium. Where there is quite rapid growth of the fungus the hypha grows onward pushing the recently developed conidium to one side but not always freeing it, and soon bears another conidium in like manner. This continues so that several conidia may be borne at short intervals on the same branch, and the successive points of the origin of the conidia are not only marked by the attached conidia but by the oval enlargements on the branch. The appearance is thus in many cases very much like that of the conidiophores of *Phytophthora*, and deBary has called attention to the same fact. Many of the conidia become free.

Early in April of the same year cultures were again started on glass slips in water. A preparation was started Tuesday afternoon, April 10, at 3 P. M. At 6 P. M. considerable growth had taken place and several conidia were developed. At 9 P. M. another examination was made and quite a profuse growth was present and numerous conidia or zoosporangia.

At 9 A. M., Apr. 11, there were many free conidia and zoosporangia and the culture abounded in the form of fructification which so closely resembles *Phytophthora*. Fresh water was now added to the preparation, a cover glass placed upon it for the purpose of studying it with the high power of the microscope and for obtain-

ing camera lucida drawings. After making several sketches of desired objects one zoosporangium was discovered emitting the protoplasmic vesicle preparatory to the differentiation of the zoospores. When the eye first fell upon it the object was in the phase represented by Fig. 18. Soon the protoplasm had all passed through the short tube and was collected in a rounded vesicle at the end. There was a slight differentiation of the protoplasm at the time of the passage, but it was little marked. The differentiation became more and more marked showing that the mass was dividing into ten to twelve polygonal bodies. The surface of the forming zoospore next the wall of the vesicle, or the periphery, is the longer, and at the middle of the outer surface of the object there soon appears a depression which gives each a curved appearance. This form becomes more and more marked and now movement begins, which first appears as a kneading of the entire mass, and as they become more and more sharply differentiated each young zoospore produces an oscillatory movement with its center nearly stationary, the movement of course much restricted by the surrounding vesicle. As they assume more distinctly the curved appearance there is developed from each end of the zoospore a cilium by the lashing of which the movement becomes more violent and results soon in the release of the swimmers when they suddenly dart away.

The movement is now a complex one. The oscillatory movement is more marked with a tendency in many cases to produce figure of 8 cycles, which is combined with a jerky progressive movement in the direction of the longitudinal axis. Frequently when they come in contact with some object larger in size, they simulate to some extent the movements of a paramæcium along some object in the water.

The form of the mature zoospore is broadly fusoid, inequilateral with pointed ends which terminate in a long cilium. After five to ten minutes the movement of the swarm spores becomes slower and finally it nearly ceases and the body undergoes plastic movements resembling somewhat that of an amoeba as represented in Fig. 24. At first this amoeboid movement is irregular but after a few minutes it assumes a definite character which tends to cut the organism into two parts. This progresses until complete

fission results in the formation of two zoospores which are oval in form with the cilium attached directly at the smaller end.

This peculiarity in the development of the zoospores is one which has not heretofore been recorded except in a preliminary paper by the writer.¹⁵ The species was at that time studied along with the seedling fungus, *A. debaryanus* (Hesse), and as this is reported as occurring also on fern prothallia (*Todea africana*) the species now under discussion was then supposed to be the same, and to this species it was doubtfully referred. But the development of the conidia is very different from that described for any other species of this genus resembling that of *Phytophthora* as stated above.

It cannot therefore at the present time be said with certainty that the zoospore formation in *Artotrogus debaryanus* is the same as that found for *A. intermedius*, though what evidence we already have on the subject might be interpreted to support that view of the case.

Where the soil is kept very damp and the air of the house is quite humid the prothallia are apt to be overrun by certain algae which choke the prothallia, shut out the air and light, prevent their proper development and frequently cause them to be completely sterile. Many of the prothallia are thus killed, sometimes entire beds or pots of them. A very common alga which I have several times observed is a variety of *Hormiscia flaccida* (Kuetz.) Lagerh. Species of *Oscillatoria* are also frequently present and produce a like injury.

If the pots or vessels in which the prothallia are grown are rested on sphagnum a layer of which can be placed in the bottom of the wardian case, and after the young prothallia have started, all of the watering be applied through this, the prothallia will do much better than if surface watering is practiced and far better than where the pots are rested in a vessel partly full of water. The air of the wardian case or of the house should not be kept too damp.

NOTE ON THE GENUS ARTOTROGUS.

Hesse who first described *Artotrogus debaryanus*¹⁶ (*Pythium de-*

¹⁵ Preliminary note on the swarm spores of *Pythium* and *Ceratiomyxa*, *Bot. Gaz.* XIX, 375, 1894.

¹⁶ *Pythium debaryanum*, etc. Halle, 1874.

baryanum Hesse) says as stated above that the zoospores are oval and provided with one cilium. *Pythium equiseti*¹⁷ Sadebeck which is generally considered to be the same plant, possesses two lateral cilia according to the descriptions, and deBary only says that the zoospore formation takes place in the oft described way.¹⁸ In *Artotrogus proliferus*¹⁹ (deBary), the author was unable to determine whether the zoospores were uniciliate or biciliate. In the vesicle they are figured as reniform, but the ultimate zoospores are described as oval, one end being narrower than the other. Double zoospores were also described which possess two light spots instead of one. These ultimately divided, but before division according to the author, the double zoospore was like that of an organism controlled by two opposing wills. This was not the case with the biciliated zoospores observed by myself in *Artotrogus intermedius*, until amoeboid movement was beginning after a period of swarming, and when fission is about to take place. Possibly deBary observed the "double" zoospores just at that time.

(In *Artotrogus pythiodes*²⁰ (R. et C.) the zoospores are described and figured as biciliate one cilium attached at each pointed end of the zoospore exactly as I have found in the case of *A. intermedius*. But in *A. pythiodes* the authors say that the zoospores absorb the two cilia, round off and germinate, i. e. they do not divide, if the observations are clear on this point. This species was found on leaves of *Wolffia mitchellii*.

Other species of the genus are as follows. *A. hydnosporus*²¹ Mont. in potatoes and in dead seedling plants: ²² *A. ferax* (deBary) in dead insects and in dead seedlings in water. *A. megalacanthus*²³ deBary in dead seedlings and parasitic in prothallia of *Todea*

¹⁷ Untersuchungen über *Pythium equiseti*, Cohn's Beitr. z. Biol. d. Pfl. III. 117.

¹⁸ Zur Kenntniss der Peronosporeen, Bot. Zeit. XXXIX., 524, 1881.

¹⁹ *Pythium proliferum* deBary, Pringsh. Jahrb. f. wiss. Bot, II, 182, 1860.

²⁰ Roze et Cornu, sur deux nouveaux types generiques pour les Familles des Saprolegnees et des Peronosporees, Ann. d. sci. nat. Bot. ser. 5, II. 72, 1869.

²¹ Montagne, sylloge, etc., p. 304, 1845.

²² Bot. Zeit. XXXIX., 562, 1881.

²³ Beitr. z. Morph. u. Phys. d. Pilze. IV., 19, 1881; Bot. Zeit. XXXIX., 578, 1881.

africana. *A. proliferus*²⁴ (deBary) saprophytic on dead seedlings and insects in water; *A. vexans*²⁵ (deBary) in dead seedlings and in diseased potatoes; *A. anguillulae-aceti*²⁶ (Sadebeck), parasitic in *Anguillula aceti*; *A. sadebeckionus* (Wittmack) producing epidemics of diseases in lupines and peas. Several other species have been imperfectly described.

A POTTING BED FUNGUS NEW TO AMERICA.

Completozia Complens Lohde.

This is an organism which is parasitic upon fern prothallia grown in forcing houses. It has been known in Europe for several years but was first found in this country during the winter of 1893-4, in the botanical conservatories of Cornell University, while studying the rotting of prothallia induced by *Artotrogus intermedius* (deBary), described in a former paragraph of this paper. Ultimately the prothallia decay but the first signs of disease when caused by this parasite alone is the appearance of a yellowish or yellowish brown color imparted by the prothallia as they lie on the soil of the pot or bed. The prothallia are so small that usually the color appears to reside in the entire prothallium when seen by the unaided eye. When examined by the aid of a microscope, however, unless the prothallium is in the last stages of the disease, the decay will be seen to be confined to "spots."

These spots vary in color from a yellowish green to yellowish brown, deep brown and finally blackish, dependent on the phase of the injury to the cell and its contents. At first the injury is confined to single cells either near together or far isolated, on the margin of the prothallium or at any point over its surface.

When the trouble is well advanced and there are numerous centers of the disease, as frequently happens, the prothallium will present a checkered or mosaic appearance, the different pieces of the mosaic being colored with the various shades of color detailed above. It also presents at this time quite a ragged appearance because many of the cells are dead and the disintegration of their contents makes holes in the plant and rifts in its edges. A short

²⁴ Pringh. Jahrb. f. wiss. Bot. II., 182, 1860.

²⁵ Jour. Bot. V., 119, 1876.

²⁶ Bot. Centralbl. XXXIX., 318, 1887.

note on the occurrence of this fungus in the United States was published by the writer in the *Botanical Gazette* for November, 1894. It is a very interesting fungus from its very simple structure, its peculiar form, mode of development, and as a plant parasite, from its being a member of the *Entomophthoraceae*, which are almost entirely parasites of insects.

The vegetative body of the fungus is a more or less compact, grape like, or botryose cluster of oval or curved hyphal branches originating from a common center, and presenting on the surface a series of convolutions formed by the external hyphal branches lying close together over the surface. This vegetative body lies within a single cell of the prothallium, sometimes completely filling even quite large cells, while at other times the body may be smaller especially in smaller cells of the prothallium, where it sometimes consists of only a few hyphal branches closely curved upon their parent cells. These hyphal branches vary from 7μ to 15μ in diameter or may even be of a greater diameter, and are one and one-half to two times longer. When the plant body in a single cell becomes mature it may spread to the surrounding cells by certain of the external hyphal branches putting out a slender germ tube which pierces the adjacent intervening wall. This is done by the tube of the hypha excreting a substance which dissolves the cellulose of the wall making a small minute pore and at the same time turning the adjacent portions of the wall brown in color. The wall of the slender thread which squeezes its way through this opening is also colored brown, and this color is frequently extended to the slender portion of the thread or tube, in which the protoplasm passes or migrates to the center of the cell as shown in figure 44.

When it has reached the center of the cell lumen the free end enlarges and forms a rotund body which finally becomes oval. At this time it is about 15μ to 25μ in diameter, with quite coarsely granular protoplasm and with one or more large vacuoles. By this time also all of the protoplasm from the original cell has moved into this oval body in the center of the cell, leaving behind only the wall of the slender tube by which it gained entrance and which is still connected with the wall of the living organism. This old wall as well as the wall of the prothallial cell where the organism entered becomes brown in color soon after the proto-

plasm has passed through into the center of the cell of the host. From the free and smaller end of this oval cell a short protuberance grows curving to one side usually rather close to the side of the parent cell. Sometimes this branches quite soon in a dichotomous manner and the two short cells curve in opposite directions. If dichotomy does not occur at the beginning of the protuberance another branch arises soon from the original cell or from the branch. These protuberances become enlarged at a very short distance from their origin forming oval cells. These in like manner produce short branches, and the process continues until a botryose or convoluted mass of cells is developed which eventually fills the cell of the prothallium, and the elements of the botryoid body become angular from mutual pressure. The wall now becomes brown in color and the glomerule appears to be mature.

In this condition if these hyphal masses are teased out from the cell of the prothallium and kept on a glass slip in a small amount of moisture germination soon takes place. Hyphal masses so teased out from the prothallium and placed under the above conditions at 5 P. M. on Feb. 22, 1894, and kept at the ordinary room temperature during the night, the temperature falling somewhat below that of the day (the temperature was 70° to 80° Fahr., up to midnight and fell 30 toward morning and rose to 66 at 9 A. M.). At 9 A. M. Feb. 23d, the preparations were examined and the mature hyphal masses were germinating. In some cases the germ tubes were 500 μ to 700 μ long and all the protoplasm had moved out in the distal half of the tube (fig. 42). In germination under such circumstances a protuberance arises from one of the individual cells of the glomerule and extends soon into a tube the diameter of which is about 10 μ . As the tube extends in length the protoplasm gradually disappears from the parent cell and passes into the tube. As the tube continues to elongate the protoplasm continues in the distal portion and the older portion of the tube becomes empty, nothing remaining but the wall. There appears to be a wall at the junction of the tube with the parent cell, if so it is formed after the protoplasm has passed into the tube. When the tube has become considerably elongated so that there is an empty portion from 200 μ to 500 μ in length there appear what seem to be transverse septa, or it may be the remains of a portion of the protoplasm situated in a thin transverse sheet in the tube. These

occur so regularly and at about 30μ to 40μ distant that the resemblance to septa is very striking if they are not really septa. If they are septa they are formed only after the protoplasm has passed these points. It may be that the growth of the tube was arrested for a certain length of time and the walls were formed while it was in this quiescent condition, or the growth of the tube may be naturally periodic. The protoplasm is coarsely granular, presenting here and there rather faint vacuoles, but there are so far as examined, no septa separating the protoplasm into distinct portions. The course of the tube is slightly sinuous, and also in an ascending position as the glomerule lay on the glass slip. Perhaps this was for the purpose of emerging from the water. After an examination the cultures were returned to the moist chamber.

While the fungus is progressing through a prothallium when one of these spore balls becomes mature, some of the cells lying adjacent to healthy cells of the prothallium germinate and grow directly into the new cell host. In doing so the germ tube is very much smaller since less energy is expended in making the perforation through the wall. After emerging from the wall in the new host cell the tube does not enlarge to the size of the tube when germination takes place in water on the glass slip, but remains about the same size as that of the perforation in the wall, until it reaches the center of the cell lumen where it enlarges into a rotund body as described above. Here it soon grows into the botryoid hyphal mass again. Other cells may germinate and course for a considerable distance over the surface of the prothallium and enter new host cells quite distant from the hyphal mass, but this has not been observed. In some cases more than one cell lying quite close to a new host cell will germinate and grow into the same. From the observations thus far made I should judge this to be quite common but not general.

The first ovoid portion of the mycelium in the center of the cell of the host is considerably larger than the curved branch which develops at its apex and frequently larger than any which follow. The more slender form of these branches and the close apposition of the branches to the primary enlarged ovoid portion suggests a striking resemblance to an oogonium and antheridium. Thus far I have not seen any conclusive evidence that these organs are

present. However, frequently the conditions are favorable for the development of another form than the purely vegetative portion of the plant, and either simple resting spores are developed, or if sexual organs are present, then oospores. The number of resting spores varies from one to ten or even twenty in large prothallial cells where the botryoid fungus is well developed. The resting spores occupy the central portion of the mass and are surrounded by the smaller and terminal cells of the plant which now are empty. The resting spores are rounded, sometimes oval, in form and when mature are bounded by a very thick wall consisting of three coats which are smooth, but sometimes appear roughened by the closely cohering cell walls of the collapsed surrounding terminal portions of the botryose mycelium. The portions which become resting cells are always the larger and central portions. They are much larger at the time of the formation of the resting spores than when the fungus is in the vegetative stage, and since at first there appear to be no cell walls intervening it would seem that their increase in size came chiefly from the outer and smaller cells giving up to them their protoplasmic contents rather than that the additional nutriment came from the cell of the host which by this time is nearly exhausted. However, this point was not determined. The wall of the young resting spore is at first very thin and the protoplasm finely granular. The mature resting

Explanation of Plate III. *Completozia complens* Lohde.

Figs. 26-30 different plants with mature resting spores showing the variation in number developed in a single plant; the resting spores surrounded by the empty peripheral cells of the plant, which may have developed conidia, or some of them entered adjacent cells of the prothallium, or possibly some of them fed the developing resting spores.

Figs. 31-32, younger stages in the development of the resting spores.

Fig. 34, plant developing resting spores at the center and a conidium from one of the peripheral cells.

Fig. 35 conidium germinating; 36, 37 and 39 germinating conidia with the germinal vesicles or proembryos developed from each one.

Fig. 40 germinal vesicle or proembryo developing the minute entrance tube which pierces the wall of the cell of the prothallium, 38 showing the entrance tube complete and the protoplasm having migrated to the center of the cell where the rotund body is formed, 41 branching of young plant in cell of host.

Drawn with aid of camera lucida and magnified 30 times more than the scale. Scale, 1 millimeter.

spore presents a very coarsely granular protoplasm the granules rounded in form and closely packed together.

Propagation also takes place by the production of non-motile Conidia from monosporous sporangia.

The conidia are oval or broadly obovate, colorless cells, with a thin wall and measure from 15μ to 25μ in diameter. In germinating, unless they are lying entirely immersed in water or in an abundance of a water which may be on the surface of the prothallium or on the soil, they do not form a mycelial tube directly. A very short tube is formed and into this the protoplasm migrates and causes the end of the short tube to swell out into an oval or oblong vesicle or the vesicle may be separated from the conidium by a constriction. This phase reminds one of the formation of the zoospore vesicle in the species of *Artotrogus*. But the formation of this tube and of the vesicle does not take place so rapidly as in *Artotrogus*, and the form of the vesicle is quite different and varies considerably in form as well as in size, but the most marked difference is that there is a firmer covering which appears to be in the nature of a well defined wall around the protoplasmic vesicle, while in *Artotrogus* there is only a protoplasmic membrane. Here the analogy ceases for zoospores are not formed. This cell is a germinal vesicle or proembryo, and from this proembryo arises the slender tube which pierces the cell of the prothallium and permits the parasite to enter. If the conidia are lying in an abundance of water they will germinate and produce a tube five to ten times the length of the diameter of the conidium. This I have several times observed, but in no such case have I observed the germ tube to enter a cell of the prothallium. Leitgeb

Explanation of Plate IV. *Completoaria complens* Lohde.

Fig. 42 botryose cluster of plant body after being placed in water, the peripheral cells germinating and forming long tubes.

Fig. 43 plant body, some of the central cells forming resting spores, and some of the peripheral ones developing conidia.

Fig. 44 plant body in one cell of the host, the peripheral cells developing tubes which penetrate adjacent cells of the prothallium.

Fig. 45 two young plants in one cell of the host having entered from an adjacent cell, early stages in the branching and development of the botryose plant body are shown.

All figures drawn with aid of the camera lucida and magnified 30 times more than the scale. Scale, 1 millimeter.

states that in such cases which came under his observation the conidium only developed a short tube and then soon died.

The conidia possess a prominent apiculus which in development is directed toward and rests partly in the stalk of the sporangium. The sporangium develops from some of the superficial cells of the botryose body, but so far as I have examined from cells which are larger than the usual external cells. The cell begins growth in an upright position or away from the moisture and appears very much like an ordinary vegetative thread which is produced when the plant is immersed in water except that it is greater in diameter. When 60μ to 80μ in length the end becomes enlarged and the protoplasm collects into the forming sporangium. While the sporangium is forming the protoplasm is more coarsely granular at the base, while at the terminal portion it is more hyaline, giving the appearance of quite large and rather numerous vacuoles. When the spore is mature it is ejected with considerable force in much the same manner as the spores of the *Entomophthoræ*.

The aerial development of the sporangia instead of aquatic is in correspondence with the nonciliated condition of the conidia. One case which came under my observation shows clearly the necessity for the aerial development of the sporangia in the formation of the conidia in this plant. In mounting an affected prothallium in water for examination I discovered a partly formed sporangium which projected out into the cavity of an old and emptied ruptured cell. In the growing condition of the prothallia in this case they were somewhat crowded so that they stood more or less erect. The sporangium then in growing also in an erect position away from the moisture would be directed into the empty cell above. Placing this prothallium in a horizontal position on the glass slip in a small quantity of water would immerse the sporangium in the water, or partly so. All of the water was then drawn off except just a sufficient amount to prevent the prothallium and fungus from drying and the preparation was placed in a moist chamber in order that from time to time it might be examined to watch the development of the sporangium. This stage of the sporangium is represented in figure 43. No farther development of this sporangium took place. But just at the base of the stalk another one began to be thrown up in a position per-

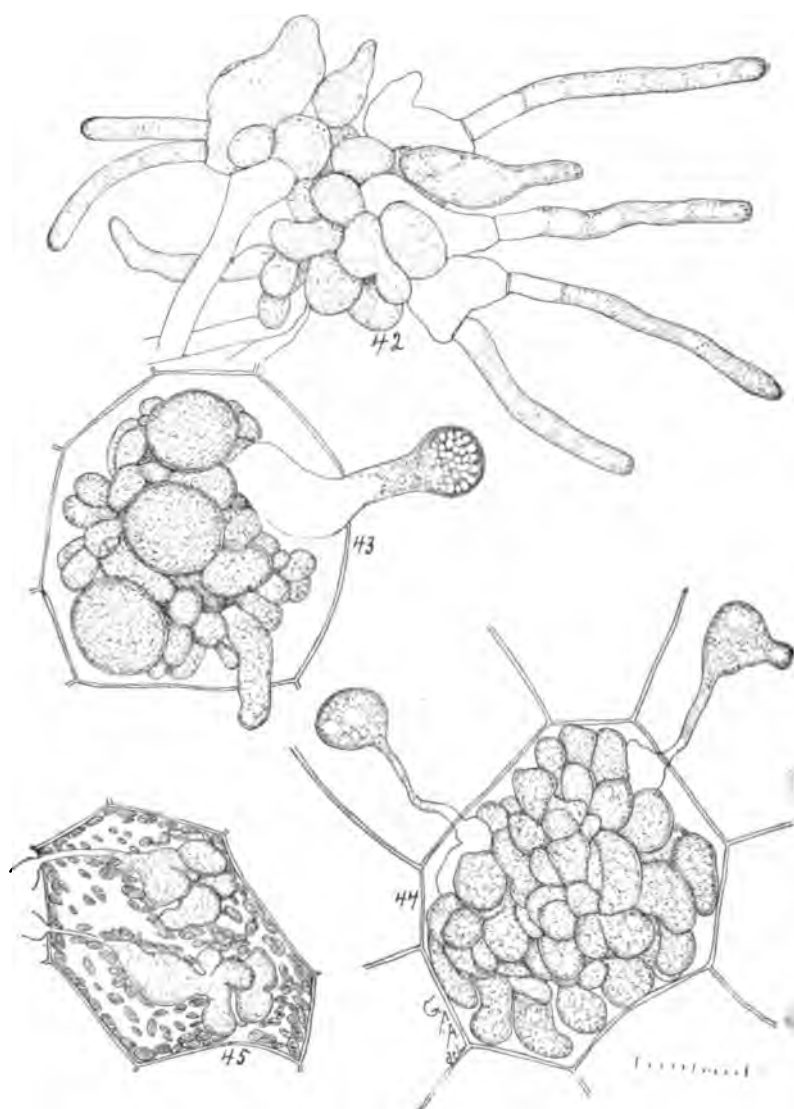


PLATE IV.—*Completoria complens* Lohde.

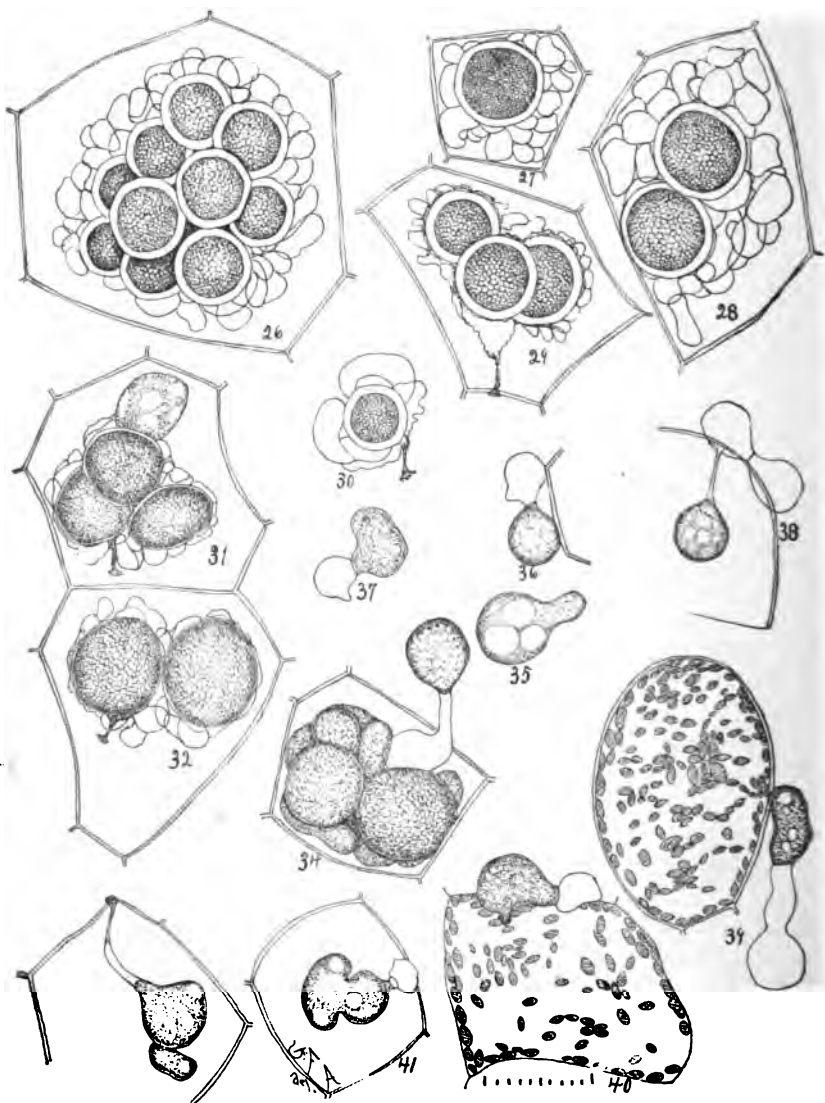


PLATE III.—*Completoria complens* Lohde.

pendicular to this prostrate one. As the new one increased in height the old one gradually lost the protoplasm both from the forming sporangium and the stalk. In the course of 4 to 5 hours the sporangium was mature and the conidium ejected, when the sporangium and stalk collapsed and remained as a flabby membrane attached to the wall of the old stalk and sporangium which was still in the water and which still remained intact.

The conidium is capable of germinating immediately when there is sufficient moisture and the behavior seems to be manifested in three different ways according to the amount of moisture, or in some cases perhaps according to the proximity of the host. If the spore is entirely immersed in water a long slender germ tube is put forth similar to the tube which is emitted from the terminal cells of the botryose body of a vegetatively mature plant. Where less water is present the conidium germinates by developing a germinal vesicle, or proembryo as described above.

From the inner face, the one lying next the prothallium cell, of the broader end of the proembryo, a minute tube is thrust out which pierces the cell wall of the host and grows out to the center of the cell lumen where in the ordinary way it enlarges into the first ovoid body of the new plant (fig's. 38, 40). In other cases probably, where there is still a less quantity of moisture, the tube from the germinating spore is directed upward or away from the host and becomes a sporangium with a very short stalk or only the short narrowed end of the sporangium which serves as a stalk. Before this conidium is ejected from this secondary sporangium if it be immersed in water, the protoplasm will grow out into a long slender germ tube. If it were only partially immersed it might as in the case of the primary sporangium noted develop a new sporangium. In the case of the primary sporangium which was immersed in water and which developed a new sporangium at the base of the old one, as described above, the base of the stalk was not entirely immersed.

As stated above the primary sporangia in the cases observed developed from some of the larger of the external cells of the cluster. In one case this took place while the inner cells were developing resting spores (fig. 34). It may be possible that the sporangia are always developed from somewhat larger and richer cells of the periphery but more likely others of the cells can

develop sporangia when the conditions of the environment, which have not all been determined, are such as to produce this tendency to fruit in the organism.

I have found the fungus in the prothallia of *Aspidium* (*Cyrtomium*) *falcatum*, *Pteris argyria* and *Pt. cretica*.

It was first described by Lohde²⁷ and was later more thoroughly studied by Leitgeb,²⁸ who grew it in a large number of fern prothallia.

A NEW CUTTING BED FUNGUS.

Volutella leucotricha Atkinson.

April 10th (1894) two cuttings, in the botanical conservatory, of carnations which were damping off were called to my attention. These were placed in a moist chamber expecting to obtain the sterile fungus or an *Artotrogus*. Two days later, 12th, the stems were well covered with a fungus which formed elevated stromata, whitish in color or with a slight tinge of flesh color. With a hand glass the stroma was seen to be surrounded by several setae, which, however, did not present at the time a dark color as is the case with the common carnation anthracnose, *Volutella dianthi* (Hals.). At the time it was supposed that this lack of color in the setae might be due to the growth. Sections of the stromata showed the structure of a *Volutella*, but the conidia were considerably smaller than those of *V. dianthi* and the setae were quite different in form as well as in color. They taper but little toward the free ends, are quite blunt at the ends and usually more times septate.

At my request Mr. R. H. Pettit, a student in my laboratory, made a separation of the fungus for me by the agar plate method. The first trial was successful and in a few days the colonies of the *Volutella* were visible to the unaided eye, the conidia having been kept watch of during the stage of germination and the formation of the colonies. The growth of the colonies is quite different from that of the *V. dianthi* as well as the development of the fruiting hyphae, and there was no longer any doubt that it was

²⁷ Ueber einige neue parasitische Pilze. Tagebl. d. 47 Vers. deutscher Naturf. u. Aertze, 203, 1874.

²⁸ Completoaria complens Lohde, ein in Farnprothallien schmarotzender Pilz. Sitzungsab. d. math. naturw. Klasse d. K. Akad. d. Wiss. LXXXIV, I, 288, 1881.

a different species from the *V. dianthi*, and the name *V. leucotricha* is here proposed for it.

Pure cultures were then started on bean and vetch stems and in a few days the characteristic stroma with the setae were developed in profusion on the surface of the stems. With the conidia from one of these cultures pure dilution cultures were made on April 20th. Instead of pouring a few drops of the first dilution into the second and from this into the third as I usually do with fungi having large conidia, the second and third dilutions were made by transferring with a double and twisted platinum needle. Plate number 1 and 2 were sufficiently separated for the study of colony characteristics and for photographing natural size. The colonies grow rather slowly and the plate No. 2 was ready for photographing on the 25th, and No. 3 on the 27th. In No. 2 the colonies were quite numerous and consequently rather small, from 4-6 mm. in diameter, while those in plate No. 3 where there were only 6 colonies were on the 27th 10 mm. in diameter. The colony steadily develops a thin and nearly circular web marked by numerous fine radiating lines which because of the exceeding thinness of the web are visible over the entire colony as it ages. There are quite regularly more dense radiating lines caused by the overlapping of certain radiating areas, and the margin shows a tendency to form roundish angles. The growth is quite sensitive to periodic changes in temperature which occur between night and day, as shown by the several concentric lines which are quite pronounced on the colony. At the center of the colony there is developed quite a compact stroma which is very much like that on a more solid substratum, like the stems of the vetch or bean. This stroma may be quite extensive and irregular in outline with a few outlying smaller and scattered ones, or there may be quite a large number of them at the center of the colony, the larger ones of course nearer the center and the smaller ones at the periphery. These individual stromata are so far like those developed in solid substrata, either in nature or culture tubes, that they are margined with the characteristic setae. A photograph of several of these growing in the agar in a Petrie dish is shown in fig. 52, plate VI, left upper corner. The photograph was taken from directly above and is magnified about 60 diameters.

In a few days after the appearance of the colonies the basidia

begin to develop. Some of them and probably the first ones are prostrate and wholly or partly immersed in the agar. They may be simple, or branched, when the branches may be opposite, or irregular, and in some cases the branches are assurgent, when most of them are thrown to one side. There is a strong tendency for the threads of the mycelium to assume a moniliform appearance by the swelling of the short cells thus producing a strong constriction at the septa. This tendency to a swelling of the cells of the mycelium is also shown to some extent in the basidia. Quite early many of the fruiting threads become erect and branch several times, the ultimate branches forming the basidia. The branches and the basidia are frequently opposite or whorled and when standing alone simulate very well the conidial fructification of a *Verticillium*. For some time the conidia are held in chains as they are developed successively on the same basidium. When moisture is sufficient, and this is usually the case in the Petrie dish, the capillarity of the film surrounding the conidia pulls them from the concatenate position and they are gathered into a globular head appearing as if they were developed in the form of a *Mucor*. Very soon at the center of the colony by the development of numerous fertile hyphae very closely, a true stroma is formed, and the conidia are held by capillarity in great masses upon the summit of the stroma.

April 24th a cell culture was prepared in a drop of nutrient agar at 5 P. M. On the following day the conidia were germinating and a group of them was photographed (46, Plate V. upper left corner). The spores here at this time were $4-5\ \mu$ in diameter. The germ tubes are quite sinuous and at this age (17 hours from time of sowing) were $15\ \mu$ to $25\ \mu$ long, and about $2\ \mu$ in diameter. In the germinating spores are a few, 3 to 5, small and very strongly refringent granules in the hyaline and homogenous protoplasm, and are quite well shown in the photomicrograph. On the following day when the culture was 40 hours old another photograph was taken (fig. 47). By this time many of the conidia showed the development of three tubes, and the tubes were now quite long. In some cases the hyphae coming in contact, anastomose, one of these conditions being shown in the photomicrograph. One day later several of the conidia showed still other tubes so that in time two to several tubes may arise from a single conidium. The anastomosing in



PLATE V.—*Volutella leucotricha* Atkinson.

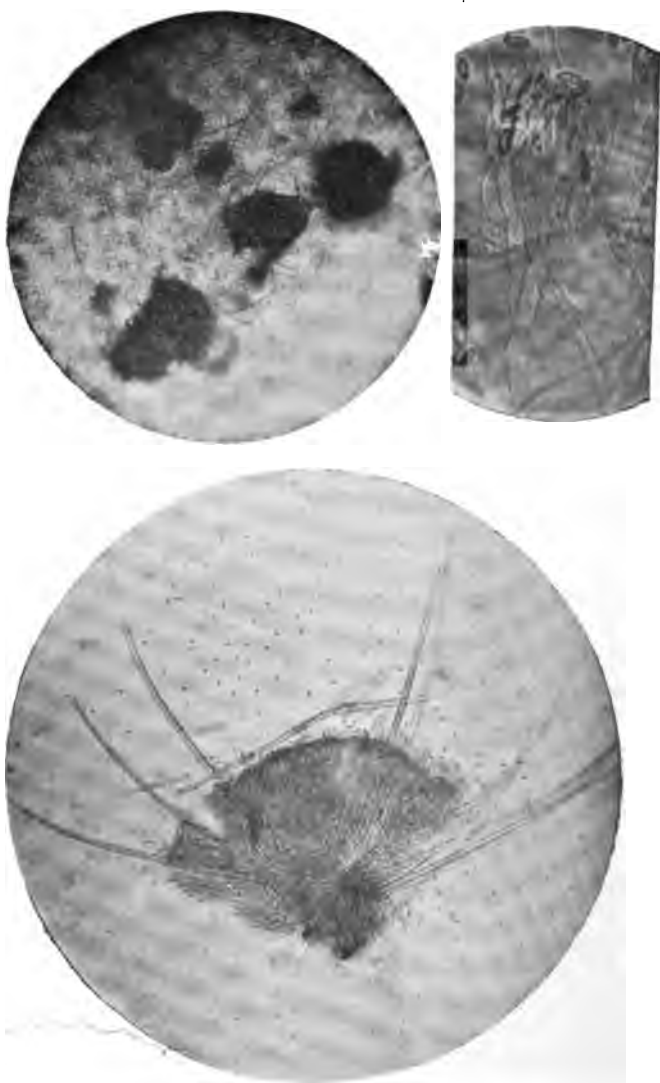


PLATE VI.—*Volutella leucotricha* Atkinson.

some cases is quite common. In this cell culture where the layer of nutrient agar was quite thin and the conidia numerous, fruiting did not take place very abundantly. In many cases the basidia are directly connected with the conidium, and in other and a majority of cases the basidia are developed from the hyphae at a variable distance from the conidium. The basidia under these circumstances are usually simple, terete and at the apex bear several conidia, which because of the rather large per cent. of water in the medium soon free themselves from the point of their origin and rest at one side. In a few cases the basidium is branched, or the fruiting hypha may bear lateral or opposite branches, and the terminal portion act as a basidium also. In this cell culture there was not the tendency for either the mycelium or the basidia to become swollen or enlarged. Two photomicrographs were taken of the conidium production in the cell culture, one showing the development of a basidium directly from the conidium (50 lower left) and one with two basidia near each other on a single thread of the mycelium (48 middle right).

In order to study the separate conidiophores, or fruiting hyphae recourse was had to the dilution culture, No. 1, in the Petrie dish. The conidia being so numerous in this dilution caused the development of numerous colonies in quite close proximity, and the fruiting was necessarily more scanty and a less tendency to the development of the stroma so characteristic of the fungus on solid substrata, or in the agar where they were not so crowded. There were therefore many scattered and independent fruiting hyphae or conidiophores. By placing a thin cover glass over portions of the plate these erect conidiophores were bent in a prostrate position, and the amount of moisture was sufficient to displace the greater amount of air so that the medium between the glass and the agar was nearly of the same density as the agar itself, and quite satisfactory photographs could be obtained when the subadjacent growth of mycelium was not too dense to interfere with the entrance of light, or to produce a hopeless confusion of threads which were not desired. Figs. 49, 51 and 54 represent point to erect its of the conidiophores in this culture, which is nearly ea. above. (Figs. 46-51 and 54 were photographed completely recover a tion of about 600 diameters).

A portion of one of the fruiting 49, 1

stools which was

from a culture on vetch stems was photographed with an amplification of 100 diameters and is shown in Fig. 53, Plate VI, lower figure. The preparation was mounted in water and the conidia which were so numerous that they would have clouded the preparation were mostly washed out. Quite a number, however, remained in the preparation, and show as minute oblong dark spots over the field of the photomicrograph. The fruiting stool is composed of numerous branched sporophores closely compacted together.

CANKER IN CUCUMBERS.

What is sometimes called canker in cucumbers has occurred during the two past winters in the horticultural houses of Cornell University. The appearance is that of a larger and deep ulcer in the stem at the surface of the ground. It occurs on plants of considerable size, on stems from 5 cm. to 1 cm. or more in diameter, the vines of which are several meters long. The ulcer has a dull brown color, the color of the external portion depending to some extent on the amount of soil which becomes worked into it. The tissues for some depth are soft and more or less putrid, dependent on the stage of the disease. It may advance so far as to cause the stem to rot off entirely, when of course the plant dies. In other cases the plant may not be ultimately killed but the ulcer has affected so deeply the vascular tissues as to interfere greatly with certain physiological functions of the plant. As the disease becomes serious the plants take on a sickly yellowish green color and become more or less limp. It soon runs its course, ending in death. During the month of December, 1894, sections of a diseased stem were placed in water and kept as described above for the seedling fungus, and in twenty-four hours a profuse growth of an *Arlotrogus*, supposed to be the common *A. debaryanus* was developed. The species was at that time not accurately determined, and at the present writing there is none of the trouble in the houses. The trouble is invited by keeping the plants in a too wet condition, just such conditions are not of the seedling fungus. It is quite possible to be described in a later paragraph may do with the etiology of the trouble.

PLATE VI.—

DAMPING OFF BY A STERILE FUNGUS.

Much of the trouble in the nature of damping off both in the forcing house and in the fields is caused by a fungus which has been under study at several different times during the last three years, but up to the present time has refused all the encouragement, which it has been possible from present experience to offer it with the hope of inducing it to develop some characteristic fruiting organs in order that its real nature and affinities might thus be made known. There are quite characteristic features of the mycelium and of certain sclerotoid bodies developed on the mycelium, and which with a little care serve to distinguish it from other known fungi.

I first observed it while studying the diseases of the cotton plant. (See Bull. Ala. Agr. Exp. Station, Dec. 1892.) In the cotton growing states it is a very frequent parasite on young cotton plants and produces a very large percentage, so far as my observation has gone, of what is known as "sore shin" in that section. The trouble is caused by the fungus growing first in the superficial tissues of the stem near the ground and disintegrating them before it passes to the deeper tissues, in other words the fungus never seems to penetrate far in the living tissues but "kills as it goes" and the tissues become brown, depressed and present the appearance of the plant having a deep and ugly ulcer at the surface of the ground. The fungus does not spread into the tissues either above or below the ulcer to any extent, but literally eats away at that point until it has severed the stem at the affected place or the plant has recovered from its effects. The plants do not seem to suffer seriously from the disease until the woody portion containing the vascular bundles is nearly or quite eaten away.

In the latter case all communication between the root and the aerial portion of the plants is cut off and of course the plant withers and dies. But frequently the stem may be eaten off so far that the plant has not sufficient strength in the remaining tissue at that point to support it and it will fall over. If the disease does not progress any farther it must be kept green for weeks, but it is rare that under those conditions which it covers sufficient strength at the parasites. These conditions frequently however when the stem may be arrested and the plant com

During the winter of 1894-5, some bean plants in the horticultural forcing houses of Cornell University were affected by this disease and quite a number of them presented brown and quite deep ulcers on the stems of the surface of the ground. A few of the plants went so far as not to be able to stand. Some of the



55.—Sterile fungus grown on slide from seedling of *Centaurea candidissima*.

worst ones were pulled up, but others which were quite badly diseased remained in the bed and all gradually recovered completely. The plants were six to ten inches in height when the trouble was called to my attention. When the plants attain this size the disease cannot make such headway, but even very young plants will frequently recover from the effects.

It is more serious when it attacks smaller seedlings, as radishes, lettuce, etc. Egg plants and cabbages as well as others are known to be affected. Both the plants in seed beds in the forcing houses have been quite seriously affected by this fungus. Lettuce is frequently eaten off at the surface of the ground and the plants supported by others near may remain erect and fresh for several days. Gradually, however, if not quickly, they wither and fall when the fungus grows in the tissues farther as a saprophyte. If such plants be placed in a moist chamber, it is not necessary to place them in water, in a day or two there will be developed on the surrounding moist paper on which it is well to place the plants, a profuse growth of mycelium composed of whitish threads. To be sure that these threads are those of this fungus and not those of some mucor it will be necessary to have recourse to the microscope. The most characteristic peculiarity of the threads of the mycelium is to be found in connection with the branching. The freshly developed threads branch freely but not profusely, they are colorless, composed of elongated cells 9μ – 11μ in diameter and the protoplasm is finely granular and rounded vacuoles. The branches extend

PLATE VI.—nt of in 30 and 60 degrees from the main
is to bet of attachment are a little curved
to with the same. At the point of attach-
e branch is considerably smaller

than either the diameter of the parent hypha or the main part of the branch, and the septum separating the protoplasm of the greater part of the branch from that of the parent hypha is situated some distance from the latter, usually 15μ – 20μ from the main thread. This portion of the branch then, the contents of which are continuous with those of the parent thread, is clavate in form. Species of *Botrytis* will occasionally be developed in diseased tissue of this kind, and sometimes develop phenomena of damping off similar to that produced by this fungus, though much more rarely, and the mycelium in its early stages cannot so far as I am able to tell be differentiated from this sterile fungus. But if a culture of the mycelium be made, in the course of a few days or in a week, if the mycelium be that of *Botrytis* the conidial stage or the clasping organs will be developed. But if it be that of this sterile fungus no such conidial stage will be developed.

Pure cultures of the fungus have been obtained at two different times. In the summer of 1892, from young cotton plants and again in February, 1895, from young lettuce plants which were damping off. It can quite easily be obtained in pure culture by transferring some of the mycelium grown in the air of a moist chamber, to some acidulated culture media. A very good medium is made by placing cuttings of bean stems, 7 to 8 centimeters long, in a culture tube and adding to this about 8 cc. of water and one drop of concentrated lactic acid. Several of these culture tubes should be prepared, and then sterilized in steam for two hours per day for three or four days in succession. The bean stems should project 2 to 4 centimeters above the liquid, and to the ends of these the mycelium can be transferred with a flamed platinum needle. Several transfers should be made and from portions of the mycelium which have been previously examined to be certain that mucors or other fungi are not present. Out of several transfers, if the growth in the moist chamber has been made with caution, a few pure cultures are quite likely to result.

Bacteria will be shut out by the acid in the medium. A culture is free from other fungi in a few days. Attention must be given be visible as a silky white growth and those conditions which favor of the bean stems growing downwarasites. These conditions are onto the surface of the glass tube. vance for several days with quite. 291, 1891.

weft. In the course of four or five days or one week, from the time that the mycelium is visible to the eye in the culture tube, there will appear first on the stems at certain points, and later on the surface of the glass tube, minute white powdery looking tufts on the mycelium. These are made up of closely and profusely branched threads, the branching sometimes presenting numerous and quite regular dichotomies, at other times quite irregular, and the terminal branches profusely lobed, the lobes standing in all directions and considerably more slender than the threads of the mycelium, and from 10μ to 20μ or more in length, occupying the distal portion of the branch for a distance from 20μ to 50μ . Another form of branching will also be present in which the closely set branches diverge at quite strong angles and are quite regularly constricted, presenting a moniliform appearance, and become eventually divided into short cells. These branches become more closely compacted and interwoven, forming rotund bodies at first white and quite small but eventually 2 to 4 millimeters in diameter and of a brown color. These bodies are probably sclerotia.

Upon the surface of these sclerotia are diverging threads with numerous moniliform cells which resemble chains of conidia. These are not true conidia since they do not easily become separated. By breaking down the sclerotia or by scraping the surface many of them become separated into chains of two or three cells or even become entirely separate. If placed in water, or in suitable medium, they will germinate, thus functioning like conidia.

The sclerotia have been kept for several months but in no case has any other stage of the fungus been developed from them.

At present it cannot be correlated with any known group of fungi but there are reasons for supposing that the sclerotia may be the resting stage of some hymenomycetous fungus. Fre-

quently the threads become united into rope like strands and

PLATE VI. — nt of which VARIOUS FUNGI.

is to be a large number, produce phases
in which their evil effects are not con-
junctures. *Phytophthora cactorum*

(L. et C.) Schroeter (*Phytophthora omnivora deBary*) was first discovered as the cause of decay of species of cactus in forcing houses. This fungus frequently destroys seedlings of trees, causing them to become brown and later to decay.

Several of the anthracnoses are known to produce genuine cases of damping off while their injury is by no means confined to this trouble. *Colletotrichum lindemuthianum* on bean seedlings is a good illustration of this, as Halsted²⁹ has already shown. The same author points out that a *Colletotrichum* on cuttings of albutilon, passiflora, clematis and jessamine causes them to damp off and in some houses ruins the bulk of the cuttings in the bed, while a *Gloeosporium* damps off rose cuttings.

Another anthracnose, *Colletotrichum gossypii* Southworth sometimes damps off seedling plants of cotton. Carnations are also affected in the same way by *Volutella dianthae* (Hals).

Halsted found a *Phyllosticta* in one case and in another case a *Septoria* growing in the stems of decaying chrysanthemums, and while this was the only fungus present it was not certainly determined as the cause of the trouble. According to Halsted bacteria also cause seedlings of cucumbers to damp off.

A species of *Botrytis* which is very common in forcing houses producing a variety of diseases of various plants frequently damps off leaves and twigs of cuttings or well rooted plants. When the houses are quite damp the fungus gains hold on the plant, probably in the axil of the leaf or branch, because the water is held at these points for a longer time, and once well seated in the tissue continues its work until the leaf or branch is rotted off. Leaves of begonias and branches of roses have been so damped off in the horticultural houses at Cornell University.

A careful inquiry would probably reveal a large number of fungi which at times produce diseases almost if not quite identical with damping off so far as external appearance goes.

TREATMENT.

In the treatment of this trouble especial attention must be given to the environment of the plants and those conditions which favor the rapid development of the parasites. These conditions are

²⁹4th Rept. N. Jr. Agr. Coll. Exp. Sta. 291, 1891.

known in most cases to be high temperature accompanied by a large moisture content of the soil, humid atmosphere, insufficient light and close apartments, and soil which has become thoroughly infested with the fungi by the development of the disease in plants growing in the same. Some excellent notes on the treatment of the disease by gardeners and horticulturists are given in the American Garden for 1890, by Meehan, Massey, Maynard, Watson, Lonsdale, Gardiner, and Bailey, and a short description of the potting bed fungus (*Artotrogus debaryanus*) by Seymour. The principal lines of treatment suggested there from the practical experience of the writers are as follows:

When cuttings are badly diseased they should be taken out, the soil removed, benches cleaned and fresh sand introduced, when only the sound cuttings should be reset. For cuttings is recommended a fairly cool house, and confined air should be avoided in all cases. As much sunlight as possible should be given as the plants will stand without wilting. When close atmosphere is necessary guard against too much moisture and keep an even temperature. The soil should be kept as free as possible from decaying vegetable matter. This is a very important matter, for several of the most troublesome of the parasites grow readily on such decaying vegetable matter and in many cases obtain such vigorous growth that they can readily attack a perfectly healthy plant which could resist the fungus if the vegetable matter had not been there to give it such a start. Soil which is dry beneath and wet on top as results from insufficient watering by a sprinkler favors the disease more than uniformity of moisture throughout the soil.

In seed beds use fresh sandy soil free from decaying matter. Avoid over watering especially in dull weather, shade in the middle part of the day only and keep temperature as low as the plants will stand.

he seedlings are badly diseased it will be wise to discard them and start the bed anew. In the early stages however they can frequently be saved by loosening the soil to dry it, and placing the pots in sunny places at such times as they will not wilt. Some advocate sprinkling sulphur on the soil and in some cases sulphur at the rate of one to thirty is mixed in the soil before sowing with good effect. When the beds are badly infested

Humphrey³⁰ advocates the entire removal of the soil, whitewashing the beds, and the introduction of fresh soil.

In houses heated by steam if it were possible to have, without too great expense, a steam chest where the pots and seed pans which are used could be placed and the soil thoroughly steamed for several hours it could be sterilized, and the finer and more delicate seedlings be grown then with little danger if subsequent care was used to not introduce soil from the beds. In testing the virulence of the *Artotrogus debaryanus* (Hesse), and of the sterile fungus, several experiments have been made by steaming pots of earth, growing seedlings in them and then inoculating some of the seedlings with the fungus while other pots were kept as checks, and all were under like conditions with respect to moisture, temperature, etc. The seedlings which were not supplied with the fungus remained healthy while those supplied with the fungus were diseased and many killed outright (see frontispiece).

CONCLUSIONS.

Damping off is caused by the growth in the seedlings or cuttings of fungus parasites which themselves are plants but microscopic in size. The plants when affected frequently present a paler green color. The tissues become soft at the surface of the ground, the plant falls over and dies. No one fungus is concerned even in the soft rot of seedlings. In related cases the plant may show a brownish ulcer at the surface of the ground which frequently increases in size until the plant is severed at this point and then dies.

Too great a moisture content of the soil, air, high temperatures, close apartments, and insufficient light not only favor the rapid growth of the parasites but they also induce a weakly growth on the part of the seedling so that it cannot so readily resist the disease.

The parasites can grow and multiply on decaying vegetable matter which is in the soil.

When once in the soil they can remain alive for months even though the soil become dry or frozen.

Soil used in seed beds or cutting beds should be free from de-

³⁰ Mass. State Agr. Exp. Sta. Bull. 402, 1891.

caying vegetable matter or care should be used that the matter is thoroughly decomposed. Fresh sand is said to be the best for small seedlings.

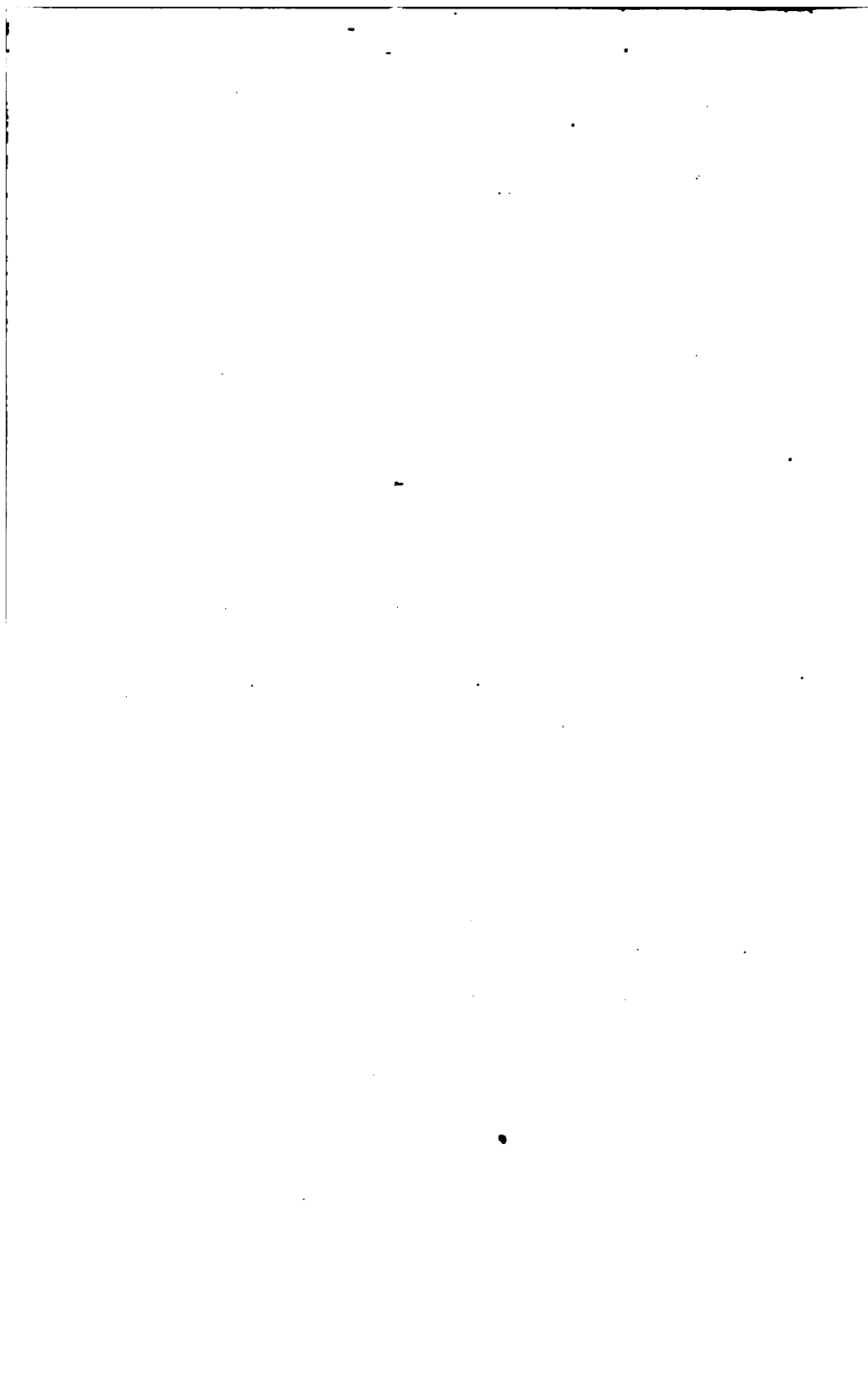
Soil in which plants have once been diseased should be discarded if it cannot be sterilized by steam heat for several hours. Fresh soil free from vegetable matter should be introduced.

Water the soil thoroughly but not to saturation and do not water oftener than actually needed.

Keep the houses well lighted, well supplied with fresh air. Do not have high temperatures, keep as even a temperature as possible. When the disease first sets in stir the soil about the plants and do everything possible to dry the soil without killing the plants or raising the temperature, keep the temperature as low as the plants will bear. If this does not save them change the soil and clean the beds by whitewashing them.

When cuttings become seriously diseased change them to fresh soil, resetting only the perfectly healthy ones.

GEO. F. ATKINSON.

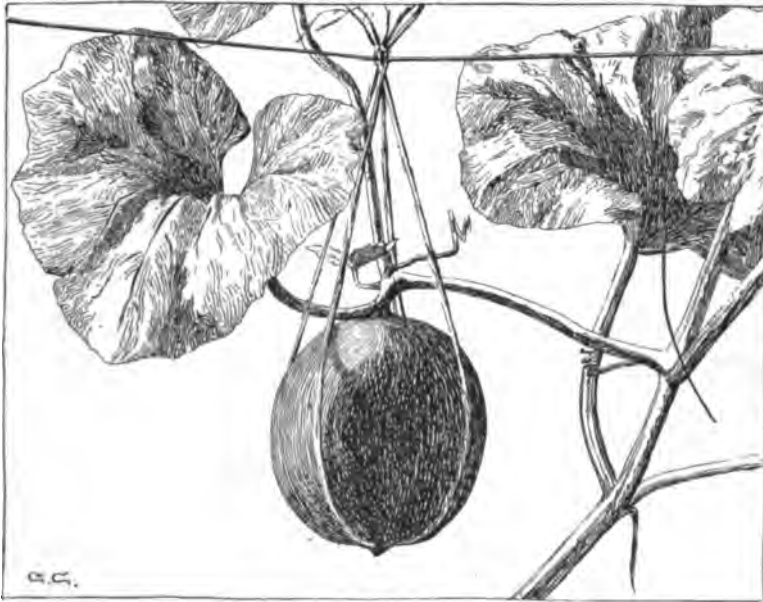


77
2826
Bulletin 95.

June, 1895.

**Cornell University Agricultural Experiment Station,
HORTICULTURAL DIVISION.**

WINTER MUSKMELONS.



By L. H. BAILEY.

**PUBLISHED BY THE UNIVERSITY,
ITHACA, N. Y.
1895.**

ORGANIZATION.

BOARD OF CONTROL:

THE TRUSTEES OF THE UNIVERSITY.

STATION COUNCIL.

President, JACOB GOULD SCHURMAN.

Hon. A. D. WHITE,	-	-	-	-	Trustee of the University.
Professor I. P. ROBERTS,	-	-	-	-	President State Agricultural Society.
Professor I. P. ROBERTS,	-	-	-	-	Agriculture.
Professor G. C. CALDWELL,	-	-	-	-	Chemistry.
Professor JAMES LAW,	-	-	-	-	Veterinary Science.
Professor A. N. PRENTISS,	-	-	-	-	Botany.
Professor J. H. COMSTOCK,	-	-	-	-	Entomology.
Professor L. H. BAILEY,	-	-	-	-	Horticulture.
Professor H. H. WING,	-	-	-	-	Dairy Husbandry.
Professor G. F. ATKINSON,	-	-	-	-	Cryptogamic Botany.

OFFICERS OF THE STATION.

I. P. ROBERTS,	-	-	-	-	-	Director.
E. L. WILLIAMS,	-	-	-	-	-	Treasurer.
H. W. SMITH,	-	-	-	-	-	Clerk.

ASSISTANTS.

M. V. SLINGERLAND,	-	-	-	-	-	Entomology.
GEO. C. WATSON,	-	-	-	-	-	Agriculture.
G. W. CAVANAUGH,	-	-	-	-	-	Chemistry.
E. G. LODEMAN,	-	-	-	-	-	Horticulture.
MICHAEL BARKER,	-	-	-	-	-	Horticulture.

Office of the Director, 20 Morrill Hall.

Those desiring this Bulletin sent to friends will please send us the names of the parties.

BULLETINS OF 1895.

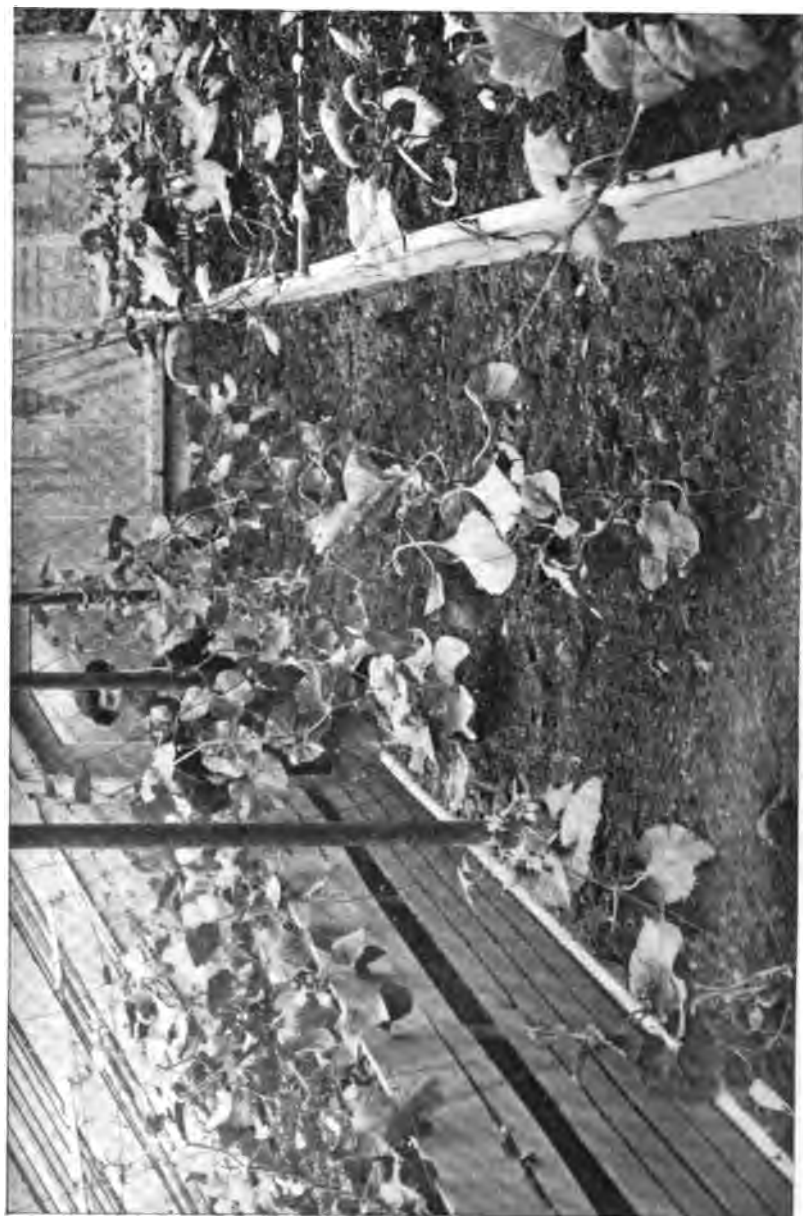
84. The Recent Apple Failures in western New York.
85. Whey Butter.
86. Spraying of Orchards.
87. The Dwarf Lima Beans.
88. Early Lamb Raising.
89. Feeding Pigs.
90. The China Asters.
91. Recent Chrysanthemums.
92. Feeding Fat to Cows.
93. The Cigar-Case-Bearer.
94. Damping Off.
95. Winter Muskmelons.

CORNELL UNIVERSITY, ITHACA, N. Y., }
JUNE 15, 1895. }

THE HONORABLE COMMISSIONER OF AGRICULTURE, ALBANY.

Sir: The following account of winter muskmelons is submitted as a bulletin in pursuance of Chapter 230 of the Laws of 1895. The growing of winter crops of vegetables and flowers under glass is an important industry in New York state and one that is rapidly enlarging. It is the most intensive and one of the most highly specialized of all the branches of agriculture, and it must play an increasingly important part in the industrial development of the future. This Station has already entered this interesting field, particularly with contributions upon the cultivation of tomatoes, frame cucumbers, beans, cauliflowers, and the heating of forcing-houses and the influences of the electric arc light upon plants under glass. We are now glad to add this paper upon the melon, which is admittedly the most difficult vegetable crop to mature in the winter months, but which can no doubt often be added with profit to those houses which are fitted for the growing of frame cucumbers or tomatoes.

L. H. BAILEY.



56.—Melon house, when the plants were four weeks from the pots.

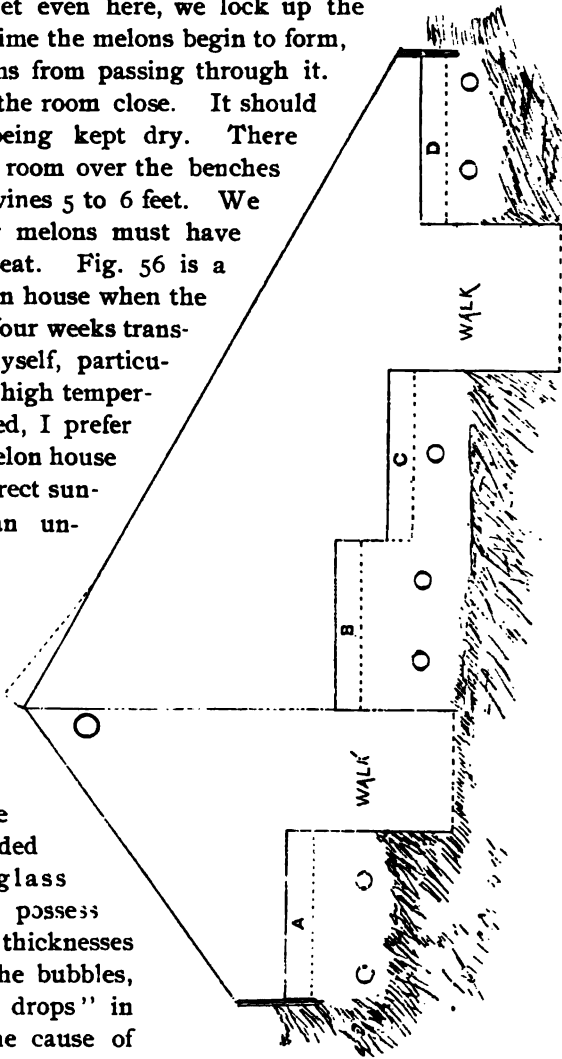
WINTER MUSKMELONS.

I. THE FORCING OF MELONS.

The forcing of melons for delivery in midwinter is practically unknown. The fruit is often grown as an early winter crop, ripening in October and early November, and the seeds are often sown in January and the melons matured in May and June. Gardeners now and then ripen a few melons in midwinter, but the fruits are almost invariably very poor or even disagreeable in quality. The writer has long been convinced that it is possible to secure good melons in December, January and February, and to grow them nearly as cheaply as the English or frame cucumbers. The attempt was first made in the winter of 1889-90, and it has been repeated more or less persistently until the present time. It was only until last winter when, profiting by all the pitfalls of our past experience and assisted by the services of our gardener, Michael Barker, we finally had a winter crop of good melons. In order to satisfy the reader's curiosity at the outset, I will say that the essentials for growing midwinter melons, as I understand them, are these: *High temperature from the start (80° to 85° at mid-day, and 70° at night); the plants must never be checked, even from the moment the seeds germinate, either by insects, fungi, low temperature, or delay in "handling"; dryness at time of ripening; a soil containing plenty of mineral elements, particularly, of course, potash and phosphoric acid; polliniferous varieties; the selection of varieties adapted to the purpose.* All these requirements seem to be easy enough of attainment as one reads them, but it has taken us six years to learn them. Others would no doubt have been more expeditious; but it should be said that no one of these conditions will ensure success, but *all of them must be put together.*

The house.—A house which is adapted to the growing of English cucumbers or tomatoes, should grow melons. The first requisite is heat. The capacity of the heating system must be

sufficient to maintain a high temperature in the coldest weather. The house should be free of draughts and large leaks. Our melon house opens into sheds at both ends, so that no outside air ever blows into it; yet even here, we lock up the house from the time the melons begin to form, to prevent persons from passing through it. We like to keep the room close. It should be capable of being kept dry. There should be ample room over the benches for training the vines 5 to 6 feet. We use benches, for melons must have strong bottom heat. Fig. 56 is a view in our melon house when the plants had been four weeks transplanted. For myself, particularly where such high temperatures are wanted, I prefer steam heat. A melon house should receive direct sunlight through an unshaded roof. In this respect melons differ from frame cucumbers, which generally thrive best under a shaded roof. The burning of the foliage by the sun is avoided by the use of glass which does not possess waves or varying thicknesses in the panes. The bubbles, flaws and "tear drops" in glass are not the cause of burning. Fig. 57 shows a cross-section of the house in which we have grown melons. We have used benches A, B and



57.—Cross section of melon house. Scale one-fourth inch to the foot.

C. The lower bench, D, has too little head room and, being the lowest, it is too cold for melons.

The soil should be very fertile. We have had good success with clay sod, which had not been manured, pulverized and mixed thoroughly with about half the bulk of well-rotted stable manure. Such a mixture contains enough quickly available nitrogen to start the plants off strongly, whilst the mechanical condition of it is so friable that all the mineral elements are easily obtained by the plants. An occasional light application of potash and phosphoric acid worked into the soil will be found to be useful. Very much of the ultimate behavior of the plants will depend upon the proper selection and mixing of the soil, and one who has had no experience in forcing-house work will rarely obtain the best results for the first year or two in preparing the earth. The mechanical condition of this soil is really more important than its fertility, for plant food may be added from time to time, but the soil itself cannot be renewed whilst the crop is growing; and, moreover, the plant food is of little avail unless the soil is well drained and aerated, not too loose nor too hard. It is impossible to describe this ideal soil in such manner that the beginner can know it. Like many other subjects of handicraft, it can be known only by experience. It may help the novice, if I say that soil which will grow good melons in the field may not be equally good in the house. Under glass, with the fierce heats in full sunshine and the strong bottom heat, heavy watering, as compared with normal rainfall, is essential, whilst the rapid drainage and the evaporation from both the top and the bottom of the bed, impose conditions which are much unlike those of the field. But the ideal condition of the soil to be maintained in the house, may be likened to the warm, mellow, rich and moist seed-bed in which every farmer likes to sow his garden seeds in spring. There is no sub-soil in-doors to catch the drainage, and a mellow field soil is often so loose and porous that the water runs through the benches and carries away the plant food. The house soil must therefore be retentive, but then there is danger that it will become puddled or sodden, or arrive in that condition which a gardener knows as a "sour" soil. This condition may be avoided by the use of the stable manure to add fiber to the soil, by the very frequent stirring

of the immediate surface with a hand weeder, and particularly by great care in watering. As the fruits begin to mature, water the house very sparingly. "The less water given, the higher will be the flavor of the fruit."* Inasmuch as old or fruiting plants require a dry house and young plants thrive best in a moister atmosphere, it is not advisable to attempt to grow successive plantings of melons simultaneously in the same house.

The bench should not be above seven inches deep, and perhaps five inches is better. If the soil is too deep, the plants grow too much and are late in coming into bearing. If the bench is four feet wide, two rows of plants, two and a half feet apart in the rows, may be grown; but if the bench is an outside one it may be handier in training if there is but a single row, with the plants about eighteen inches apart. It should always be borne in mind, however, that at least twice the number of plants should be set in the beds which are ultimately to grow in them for there will almost certainly be accidents and black aphids, and mildew and damping-off. When the plants have stood in the benches two or three weeks, the weak ones may be pulled out. It is a good practice, when but a single row is planted, to set the plants nearer one side than the other, and then leave the wider side of the bench empty, and add the soil to it as the plants need it. In this way fresh forage is obtained for the roots in soil which has not been leached of its plant food nor impaired in its mechanical condition; and the plants will make a steady growth from start to finish, rather than an over-vigorous one at first. If there is too much soil, the roots spread through it quickly and the plants run at once to vine.

Sowing and transplanting.—The seeds should be sown in pots. We like to place a single seed in a 2-inch pot, and in about three weeks—if in summer or fall—to transplant the seedling into a 4-inch pot. In two or three weeks more, the plant may be set permanently in the bench. The record of one of our crops is as follows: Seeds sown August 4th; repotted August 30th; transplanted to bench September 10th; first fruit picked December 6th; crop all harvested for Christmas.† Fig. 58 shows the size of a good

* George Mills, *A Treatise on the Cucumber and Melon*, 73.

† It should be said that the forcing season at Ithaca is unusually cloudy, and that, consequently, these dates of maturity are somewhat later than they may be in sunnier regions.



6a.—*Blenheim Orange melon.* Natural size.

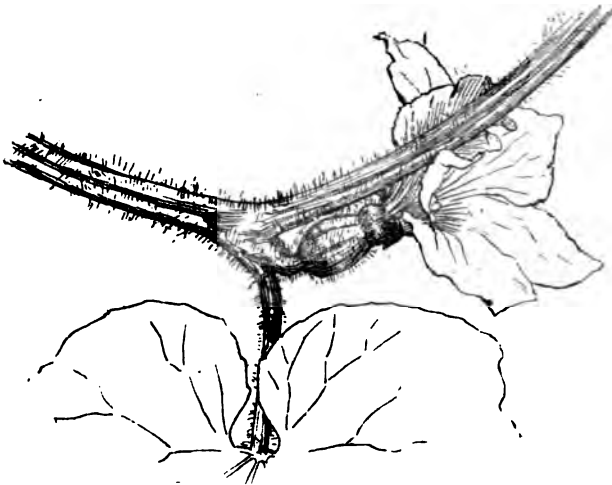
melon plant as it leaves a 4-inch pot for the bench. It is very important that the plants should not become pot-bound, nor stunted in any other way. It is only strong, pushing plants which give satisfactory results.

Training.—The plants are “stopped”—the tip of the leader



taken off—as soon as they become established in the bench, or sometimes even when they are transplanted. This pinching-in is practiced for the purpose of setting the plant at once into fruit-bearing, and to make it branch into three or four main shoots. All the weak or “fine” shoots are removed as fast as they appear, so that the plant does not expend its energy in the making of useless growth. The three or four main vines or arms are trained

divergently upon a wire trellis, and as soon as a shoot reaches the top of the trellis—four or five feet—it is stopped. This trellis is made simply of light wire strung both horizontally and vertically, with the strands about a foot apart in each direction. To these wires, the vines and fruits are tied with raffia, or other soft, broad cord. It must be remembered that the fruit is borne along the main branches, and that all small or "blind" growths should be nipped out as soon as they start. The fruits should hang free from the vine, never touching the ground. It will generally be necessary to hang them to a wire, as shown on the title-



59.—Pistillate or female flower of melon. Natural size.

page, by making a sling of raffia. They will then not hang too heavily on the vine, nor break off,—as they sometimes do if unsupported.

Pollinating.—The flowers must be pollinated by hand. Melons are monœcious,—that is, the sexes are borne in separate flowers on the same plant. The first flowers to open are always males or staminate, and it may be two weeks after these first blossoms appear that the females or pistillates begin to form. There is nearly always a much larger number of males than females, even when the plant is in full bearing. Fig. 59 is a female, or pistillate flower, natural size. It is at once distinguished by the little

melon, or ovary, which is borne below the colored portion of the flower. The male or staminate flower is seen in Fig. 60. It has no enlargement or melon below, and the flower perishes within a day or so after it opens. Pollination is performed in the middle of the day, preferably when the house is dry and the sun bright, so that the pollen is easily detached from the male flower. A male flower is picked off, the petals or leaves stripped back, and the central or pollen-bearing column is then inserted into a pistillate flower, and there allowed to remain. That is, one male flower is used to pollinate one female flower, unless there should happen to be a dearth of male flowers, in which case two or three female flowers may be dusted with one male. If the house is too cool and too moist, the pollen will not form readily, and there are some varieties which are poor in pollen when grown under glass. Every pistillate or female flower, except the first two or three which appear, should be pollinated, although not more than four or five on each plant should be allowed to perfect fruit. It is very rare that even half of the female flowers show a disposition to set fruit. It is best to ignore the very first flowers which appear, for if one strong fruit is set much in advance of the appearing of other pistillate flowers, it will usurp the energies of the plant and the later fruits will be likely to fail.



60.—*Staminate or male melon flower.*
Natural size.

Varieties.—The general varieties of field melons do not succeed well in the house. We have tried various common melons for forcing, but the only one which was adapted to the purpose is Emerald Gem. We have had the best success with the English frame varieties, particularly with Blenheim Orange. All these melons are small (winter specimens weighing from $1\frac{1}{4}$ to $1\frac{1}{2}$ lbs.), with thin netted rinds, and a red or white flesh of high quality.

Blenheim Orange (Fig. 62), is a red-fleshed melon of medium to medium large size, with a very irregularly and variously barred

rind, scarcely ribbed, short-oval in shape, highly perfumed and of the very highest quality. This has been our favorite winter melon. In midwinter we have had it with all the characteristic



63.—*Masterpiece melon. Natural size.*

flavor and aroma of autumn fully developed. It is also an early melon, in season coming in just after Emerald Gem.

Hero of Lockinge (Fig. 61, the cut melon on top). This ripens just after Blenheim Orange. It is a firm melon of medium size, with white flesh, dark in color with a few very prominent irregular bars, not ribbed, globular, the flesh tender and excellent but

less aromatic than Blenheim. This is one of the best of the frame melons.

Lord Beaconsfield follows Lockinge, but it has not been valuable



64.—*Empress melon.* Nearly natural size.

with us. It is a dull green globular-conical misshapen melon without ribs or netted markings, and a soft green flesh which is poor.

Masterpiece (Fig. 63). A very attractive melon with distinct ribs or segments and a closely and prominently reticulated rind ; globular-oval, of medium size, becoming yellow, with a thick and

very rich red flesh. One of the very best, ripening ten days or two weeks after Blenheim Orange.

Empress (Fig. 64). A globular melon of rather small size, ribless, but marked with very coarse angular bars; flesh pale orange, of good quality. A pretty little melon, with curious markings, ripening with Masterpiece. Less desirable than Blenheim or Masterpiece.

Monarch (Fig. 61, front row, left). A good sized melon, with sparse markings, except about the blossom end, dull yellow in color, not ribbed; flesh thick and solid, red, of excellent flavor. Ripens with Masterpiece. Our stock of this melon appears to have been mixed, and we have also grown a cross with Lockinge. Because of its variable character and somewhat unattractive appearance, we prize it less than some other varieties; but it is probable that a pure stock would have given more satisfactory results.

The varieties, then, which we chiefly recommend for forcing, are Blenheim Orange, Hero of Lockinge, and Masterpiece, with, perhaps, Emerald Gem for early. A good crop of melons in the winter months is an average of three fruits to the plant. This means that some plants must bear four or five melons, for there will almost certainly be some plants upon which no fruit can be made to set. The larger the fruits, the fewer each plant can mature. Four to five pounds of fruit to the vine is all that can reasonably be expected after November. The fruits will continue to ripen for a week after they are picked. Ordinarily, if seeds of Emerald Gem, Blenheim Orange, Hero of Lockinge, or other early varieties are sown August first, fruits may be expected early in November. If the fruits are desired in January, there should be two to three weeks' delay in sowing. All plants grow slowly in the short, dark days of midwinter. The novice should not attempt to secure fruits later than Christmas time, for the growing of melons should be undertaken cautiously at first.

Insects and diseases.—There have been three serious insect enemies to our winter melons—black aphid, mites (*Tetranychus bimaculatus*) and mealy-bug. The best method of dealing with these pests is to keep them off. It is a poor gardener who is always looking for some easy means of killing insects. If the

plants are carefully watched and every difficulty met at its beginning, there will be no occasion for worrying about bugs. A fumigation with tobacco smoke twice a week will keep away the aphids; but if the fumigation is delayed until after the lice have curled up the leaves, the gardener will likely have a serious task in overcoming the pests, and the plants may be irreparably injured in the meantime.

For mites, keep the house and plants as moist as possible. At all events, do not allow the plants to become so dry that they wilt, for this neglect will sap the vitality out of any plant, and it falls an easy prey to insects. When the mites first appear upon the foliage,—if the gardener should be so unfortunate as to have them,—knock the pests off with a hard stream of water from the hose, or pick the affected leaves and burn them. If the plants become seriously involved, so that all the leaves are speckled-grey from the work of the minute pests on the under side, then destroy the plants. Melon plants which have become seriously checked from the attacks of insects or fungi are of no further use, and they may as well be destroyed first as last.

Mealy-bugs are easily kept off by directing a fine hard stream against them, when watering the house. When these bugs first appear, they usually congregate in the axils of the leaves, and a strong stream of water greatly upsets their domestic arrangements. In one of our melon experiments, when the mealy-bug got a foothold, we picked them off with pincers. We went over the vines three times, at intervals, and eradicated the pests; and the labor of it—the vines were small—was much less than one would suppose.

There are two troublesome fungous disorders of frame melons. One is the mildew (*Erysiphe Cichoracearum*), which appears as whitish mold-like patches on the upper surface of the leaves. It also attacks cucumbers. It may be kept in check by evaporating sulphur in the house, as described in Bulletin 96. It is imperative that the sulphur do not take fire, for burning sulphur is fatal to plants.

The second fungus is canker or damping-off.* This usually

*For a discussion of this fungus by the botanist, see Bull. 94, p. 264.

attacks the plants after they have attained some size in the benches, sometimes even when they are in fruit. The vine stops growing, turns yellow, and finally begins to wilt. If the plant is examined at the surface of the ground and just beneath the soil, the stem will be found to be brown and perhaps somewhat decayed, the bark sloughs off, and sometimes deep ulcers are eaten into the tissue. In this stage of the disease nothing can be done to save the plant. The treatment must be a preventive one. Keep the soil dry about the stem. Do not apply water directly at the root. In order to keep the soil dry, it is an excellent plan to hill up the plant slightly. If a little sulphur is mixed with the soil about the plant, the spread of the fungus will be checked. Some persons sprinkle lime about the plant to check the fungus.

II. WINTER MELONS FOR FIELD CULTIVATION.

There is an interesting class* of melons, little known in this country, which gives fruits of long-keeping qualities. These are known as the winter or scentless melons. They are mostly of an oblong shape, with green or grayish hard rinds and commonly a white or green flesh which often lacks almost entirely the characteristic aroma of the muskmelon. The leaves are generally longer and greener than those of the common melons. The fruits are picked just before frost, when they appear to be as inedible as squashes, and are stored in a fruit-room to ripen. The true winter melons require a long season. We have planted them upon good soil on the first day of June, and they have barely come to maturity before frost. There is little difficulty in keeping some of the varieties until Christmas, if they do not get too ripe in the field, if the fruits are not allowed to become frost-bitten, and if the room is cool and rather dry.

There are two general types amongst the winter melons which we have grown. One type has a solid interior, like a cucumber, and the seeds are imbedded firmly in the structure of the fruit. The other class has a soft interior and the loose seeds of ordinary melons. To the first class belongs the Winter Pineapple, a var-

* *Cucumis Melo*, var. *inodorus*, Naudin, Ann. Sci. Nat. Bot. 4th ser. 11, p. 56.

iety which seems to me to be indistinguishable from the Green-fleshed Maltese melon (*Melon de Malte d'Hiver à chair verte*) of the French. It is variable in shape and size but is commonly pyriform and clear yellowish green, with a green inodorous flesh of fair quality for its class.

There are a number of good varieties in the second, or loose-seeded class. The one which we have liked best is the French



65 — *Winter Climbing Nutmeg melon.*

Winter Climbing Nutmeg (*Melon Brodé vert grim pant*), shown in Fig. 65. This photograph (Fig. 65) was taken in November, when the fruits had become somewhat shrivelled. It has a sweet and good green flesh. The seeds are very small. The fruit is small, ribbed, and very dark green with yellow furrows. It keeps well until December. Another good melon is the White Antibes of the French (*Melon Brodé d'Antibes blanc d'Hiver à chair verte*). It is an egg-shaped melon of good size, bright green until full

maturity, and hard-shelled. It is a very long keeper. The Red-fleshed Maltese melon excels other melons of this class in quality, the flesh being aromatic and rich, but is not so good a keeper as the green-fleshed sorts.

The White Japan melon (Fig. 66), whilst not a winter variety, is nevertheless a good keeper if the fruits are not fully ripened



66.—*White Japan melon.*

when picked. We have kept it easily until well into November. It is a small globular lemon-yellow melon, of variable character as regards surface markings, a soft and stringy but good and aromatic flesh, and many small seeds. The blossom scar is usually very large, as seen in the specimen at the right in Fig. 66.

In general, I should say that these winter melons are worth growing for home use. The quality is not so good as that of the summer melons, but this defect is overbalanced by their long-

keeping qualities. From my present knowledge of them, I should grow chiefly the Winter Climbing Nutmeg, the White Antibes and perhaps the Winter Pineapple. These melons are also useful for the making of conserves.

SKETCH.

1. Muskmelons for winter use may be obtained in two ways,—by forcing them under glass, and by growing the long-keeping varieties in the field.

2. Melons under glass are usually harvested in late fall or in spring in this country. It is difficult to bring them to a good size and high flavor in the winter months, although this can be done if the proper conditions are secured.

3. The requisites for ripening melons under glass, particularly in winter, are these : a temperature of 80° to 85° at midday in the shade, and 10 or 12 degrees lower at night ; a continuous and steady growth from the time the seeds germinate ; a soil rich in mineral elements and without much stimulating nitrogen ; dryness at time of ripening ; great care in preventing the attacks of insects and fungi ; hand pollination ; the selection of varieties adapted to the purpose.

4. The melon house should have all the direct sunlight which is obtainable, and it should be capable of being easily heated. There should be a space of five or six feet above the benches, to allow of training, but all height beyond this is of little avail. Melons demand unshaded roofs. (Page 277).

5. Muskmelons should be grown in benches, with strong bottom heat, such as is supplied to frame cucumbers and tomatoes. The soil should be five or six inches deep, and each plant should have about four square feet of ground room. But it must always be remembered that, because so many accidents are likely to overtake the plants, two or three times the number of plants should be transplanted into the benches which it is designed shall ultimately stand there. (Page 280).

6. A soil made of pulverized strong clay sod mixed with half its bulk of old manure, is fit for melons. Raw, fresh manure gives too much stimulating growth. Subsequent fertilization may be effected by applications of liquid manure or mineral fertilizers. (Page 279.)

7. Young and rapidly growing melon plants demand free watering, and a moist atmosphere also keeps down the mite and red spider ; but when the fruit begins to ripen, and when the

flowers are being pollinated, the house must be dry. It should be borne in mind, however, that a moist atmosphere at any time encourages mildew and canker. (Pages 279, 283, 288.)

8. The house should be ventilated cautiously, and all draughts and sudden changes in temperature should be avoided.

9. Early varieties mature fruits in three months from the seed, except in midwinter, when considerably more time must be allowed. The seeds are sown in thumb-pots or 2-inch pots, repotted into 4-inch pots, and thence transplanted to the benches. The plants must never be allowed to become pot bound. (Page 280.)

10. The plants are "stopped" before they show a tendency to run, and three or four strong shoots are trained upwards on a wire trellis. All weak secondary growths should be removed as soon as they start. These main shoots are stopped when they reach a height of about four feet. (Page 281.)

11. Melon flowers must be hand-pollinated. This operation is best done in a sunny day, when the house is dry. (Page 282.)

12. Good varieties for house use, in order of ripening, are Emerald Gem, Blenheim Orange, Hero of Lockinge and Master-piece. The best single one in this list is probably Blenheim Orange. (Pages 283).

13. From November until spring, a good melon should weigh from 20 to 24 ounces, and an average of three melons to the plants is all that can be expected. Before November, a heavier yield may be obtained. (Page 283, 286).

14. The insects which have seriously troubled muskmelons in our houses are the black aphid, two-spotted mite and mealy-bug. Fumigating with tobacco twice a week will keep the aphid out. A moist atmosphere holds the mite in check. Knock off the mealy-bug with a hard stream from the hose. (Page 286).

15. Two fungi attack winter melons. The mildew, appearing as frosty patches upon the leaves, is destroyed by sulphur fumes. The canker or damping-off is best prevented by keeping the soil dry about the plants and by mixing sulphur in the soil. (Page 287).

16. Winter melons for field cultivation require a long season, and they are picked just before frost and before they have become edible. They ripen slowly in a cool fruit room, often keeping until Christmas. Some of the leading varieties are Winter Climbing Nutmeg, White Antibes and perhaps Winter Pineapple. These melons are mostly lacking in aroma and they do not have the high quality of other melons. (Pages 288 to 291).

L. H. BAILEY.

✓ 30,000
N7
C82b

75.6

UNIV. OF MICH.

JAN 18 1909

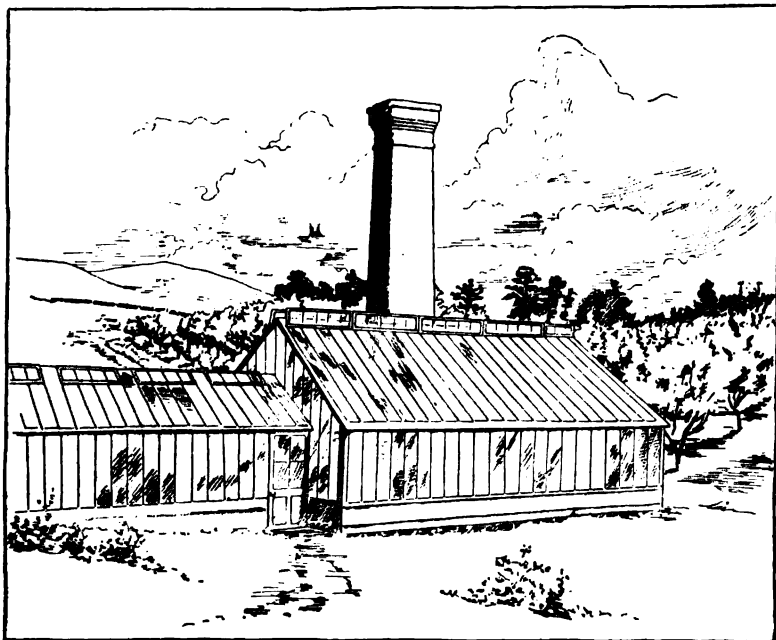
Bulletin 96.

June, 1895.

Cornell University Agricultural Experiment Station.

HORTICULTURAL DIVISION.

Forcing-House Miscellanies.



By L. H. Bailey and E. G. Lodeman.

PUBLISHED BY THE UNIVERSITY.

ITHACA, N. Y.

1895.

ORGANIZATION.

BOARD OF CONTROL: THE TRUSTEES OF THE UNIVERSITY.

STATION COUNCIL.

President, JACOB GOULD SCHURMAN.

Hon. A. D. WHITE,	-	-	-	-	Trustee of the University.
Professor I. P. ROBERTS,	-	-	-	-	President State Agricultural Society.
Professor I. P. ROBERTS,	-	-	-	-	Agriculture.
Professor G. C. CALDWELL,	-	-	-	-	Chemistry.
Professor JAMES LAW,	-	-	-	-	Veterinary Science.
Professor A. N. PRENTISS,	-	-	-	-	Botany.
Professor J. H. COMSTOCK,	-	-	-	-	Entomology.
Professor L. H. BAILEY,	-	-	-	-	Horticulture.
Professor H. H. WING,	-	-	-	-	Dairy Husbandry.
Professor G. F. ATKINSON,	-	-	-	-	Cryptogamic Botany.

OFFICERS OF THE STATION.

I. P. ROBERTS,	-	-	-	-	Director.
E. L. WILLIAMS,	-	-	-	-	Treasurer.
H. W. SMITH,	-	-	-	-	Clerk.

ASSISTANTS.

M. V. SLINGERLAND,	-	-	-	-	Entomology.
GEO. C. WATSON,	-	-	-	-	Agriculture.
G. W. CAVANAUGH,	-	-	-	-	Chemistry.
E. G. LODEMAN,	-	-	-	-	Horticulture.
MICHAEL BARKER,	-	-	-	-	Horticulture.

Office of the Director, 20 Morrill Hall.

Those desiring this Bulletin sent to friends will please send us the names of the parties.

BULLETINS OF 1895.

84. The Recent Apple Failures in western New York.
85. Whey Butter.
86. Spraying of Orchards.
87. The Dwarf Lima Beans.
88. Early Lamb Raising.
89. Feeding Pigs.
90. The China Asters.
91. Recent Chrysanthemums.
92. Feeding Fat to Cows.
93. The Cigar-Case-Bearer.
94. Damping Off.
95. Winter Muskmelons.
96. Forcing-House Miscellanies.

CORNELL UNIVERSITY, ITHACA, N. Y., }
June 26, 1895. }

THE HONORABLE COMMISSIONER OF AGRICULTURE, ALBANY :

Sir : The prolific requests of correspondents and the suggestions which come of experiment station investigation, are bound to result in the accumulation of many pieces of work which are more or less fragmentary and which are of insufficient length or importance for separate publication. Some of the more valuable of such investigations relating to the forcing-house industry, which have recently accumulated, are here gathered and sorted into convenient form for preservation ; and I take the liberty to suggest the publication of them as a bulletin under chapter 230, of the Laws of 1895.

L. H. BAILEY.

CONTENTS.

Remarks upon the Heating of Forcing-Houses. L. H. Bailey.

Page 297.

Advises steam in preference to water for heating all large forcing establishments which are frequently modified or extended and where the runs are devious and crooked, particularly if a high temperature is required. Finds a high expansion tank to be more useful than a low one, in heating with water in closed circuits. Reports satisfactory results with illuminating gas as a fuel.

Lettuce. L. H. Bailey. Page 307.

The requisites for growing lettuce under glass are a low temperature, solid beds or at least no bottom heat, a soil free of silt and clay but liberally supplied with sand, and careful attention to watering. Rot and leaf-burn are prevented by a proper soil and temperature, and care in watering and ventilating.

Celery under Glass. L. H. Bailey. Page 315.

Describes the growing of celery for delivery in May and June, when the supply of stored celery is exhausted.

Cress in Winter. L. H. Bailey. Page 316.

Forcing Egg-plants. E. G. Lodeman. Page 318.

Egg-plants can be successfully grown under glass, but they require a very long season, a high temperature and full sunlight. Insects are troublesome, particularly the two-spotted mite, which is best handled by not allowing it to gain a foothold. Early Dwarf Purple is the best variety for forcing.

Winter Peas. E. G. Lodeman. Page 325.

The tall or half-dwarf peas force readily in a cool house. The very dwarf varieties yield too little to pay for growing.

Bees in Greenhouses. E. G. Lodeman. Page 327.

Details a vain attempt to utilize bees in pollinating tomatoes.

Methods of Controlling Greenhouse Pests by Fumigation. E. G.

Lodeman. Page 328.

Bugs do no harm when absent. We should therefore treat the greenhouse rather than the bugs, that we may not have them. Instructions are given for the use of tobacco smudge, bisulphide of carbon, hydrocyanic gas and sulphur.

Treatment of Carnation Rust. E. G. Lodeman. Page 333.

Copper fungicides are efficient.

FORCING-HOUSE MISCELLANIES.

REMARKS UPON THE HEATING OF FORCING-HOUSES.

The only system of heating now in use in large forcing-houses in this country is that of the closed circuit, in which the warming medium is conducted through small wrought-iron pipes, which may be laid either above or below the benches. The warming medium is either steam or water, and there are strong partisans of each. We had never taken sides in the controversy over the comparative merits of the two, for we have believed that each has superlative merits for particular purposes. Various tests which we have made, however, show that in large unshaded forcing-houses where the runs are various and crooked, and especially where high temperatures are wanted,—as in forcing tomatoes, melons and cucumbers—steam has distinct advantages over water. Our first experiment was made in the winter of 1891-2, and the results were published in Bulletin 41. The general practical results of this test—which was an extended one—were these :

1. *The temperatures of steam pipes average higher than those of hot water pipes, under common conditions.*
2. *When the risers or flow pipes are overhead, the steam spends relatively more of its heat in the returns, as bottom heat, than the water does.*
3. *The heat from steam distributes itself over a great length of pipe more readily than that from hot water, and steam, therefore, has a distinct advantage for heating long runs.*
4. *Steam is preferable to hot water for long and crooked circuits.*
5. *Unfavorable conditions can be more readily overcome with steam than with water.*

In this first experiment, the steam system was more economical of coal than the water system, although we were then convinced that there was no necessary important difference between steam

and water in economy of fuel. Objections were made to our conclusions by partisans of water heating, largely upon the score that our water heater was not a good apparatus. This objection had little merit, however, because our conclusions were drawn from observations made upon the heat-carrying power and mechanical movements of the two media, and these fundamental results must have been approximately the same in whatever style of heater was used. However, we repeated the test the following winter (Bulletin 55) under conditions particularly favorable to the water system. In this case, a portable water heater was used alternately for water and steam heating, the piping and other conditions being constructed for water and remaining the same for both media. The essential results of the first test were reaffirmed, except that the coal consumption was practically the same in the two systems.

In this second test, we took up a few points for more particular study. One of these was the effect of crooks and angles upon the movements of steam and water. Our conclusion was that

6. The addition of crooks and angles in pipes is decidedly disadvantageous to the circulation of hot water, and of steam without pressure; but the effect is scarcely perceptible with steam under low pressure.

Figures show this admirably. A straight run of riser or flow 21 feet long, had a piece some over two feet long cut out of it, and a set-off or crook put in its place by running the pipe out sideways, at right angles, about four feet, letting the set-off reënter the riser at the expiration of the two feet. That is, instead of a continuous piece of pipe, we had a pipe with four angles or elbows in it. The temperatures of the inside of the pipes were taken at the boiler and at the far end of the riser, both with steam and water and with and without the set-off. A part of the records were as follows.

A. Water Circulation.—

1. Straight run. Dec. 22—Jan 16

Average temperature at boiler	-	-	159°
Average temperature at far end of riser	-	-	145°

2. With set-off. Feb. 10-25

Average temperature at boiler	-	-	178°
Average temperature at far end of riser	-	-	131°

B. Steam Circulation, no perceptible pressure on the guage.—

1. Straight run. Jan. 16-31

Average temperature at boiler	-	-	204°
Average temperature at far end	.	-	184°
2. With set-off. Jan. 31-Feb. 10

Average temperature at boiler	-	-	193°
Average temperature at far end	-	-	123°

C. Steam Circulation, 1lb. or more pressure.—

1. Straight run. Jan. 16-31

Average temperature at boiler	-	-	211°
Average temperature at far end	-	-	212°
2. With set-off. Jan. 31-Feb. 10

Average temperature at boiler	-	-	211°
Average temperature at far end	-	-	212°

It is thus shown (*A*) that whilst the readings at the two ends of the run, with water, were very nearly the same in the straight pipe, they were widely different when the crook or set-off was inserted. Not only was the temperature at the farther end less with the crooked run than with the straight one, but the temperature at the boiler was much higher, showing that the impediment had increased the pressure and consequently the temperature in the fore part of the run. This explains why it is that water pipes are often so hot near the boiler but so cold at the further end of the house: some impediment, like crooks, dips, elbows or partially filled pipes, is probably in the circuit. With steam under low pressure, however (*C*), there was no difference in the temperatures at the two ends between the straight and crooked runs.

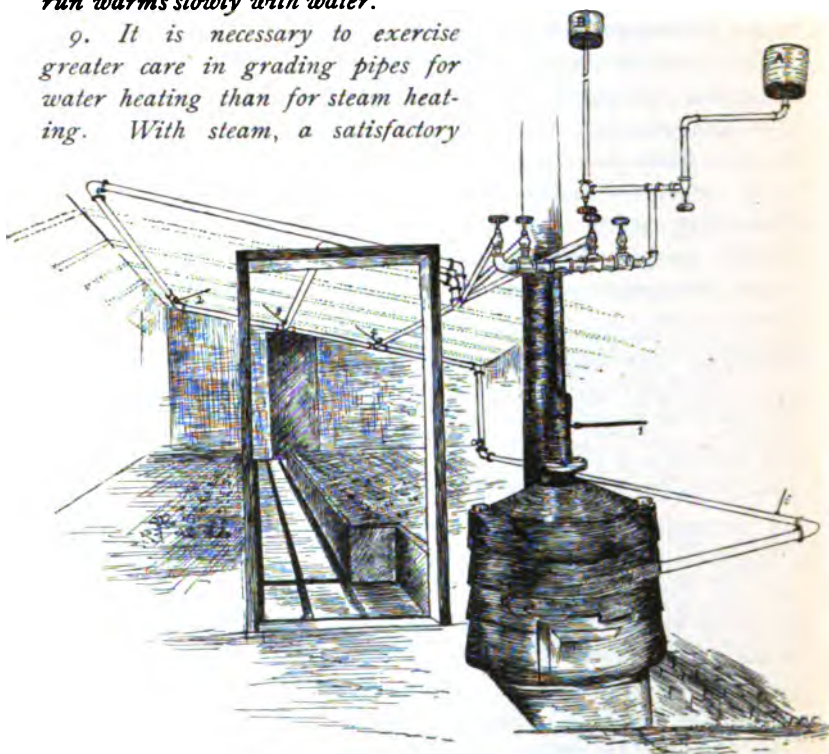
Another point receiving attention in the second experiment was the time required to heat up steam and water systems. It is said by many persons that inasmuch as water begins to move before steam forms, therefore hot water will warm up a house sooner than steam. It is true that water moves off first but it travels slower; it is soon overtaken by the steam. Our tests showed that

7. *In starting a new fire with cold water, circulation begins with hot water sooner than with steam, but it requires a much longer time for the water to reach a point where the temperature of the house is materially affected than for the steam to do so.*

We also found that

8. *The length of pipe to be traversed is a much more important consideration with water than with steam, for the friction of the water upon the pipe is much greater than the friction of steam, and a long run warms slowly with water.*

9. *It is necessary to exercise greater care in grading pipes for water heating than for steam heating. With steam, a satisfactory*



67.—*Experimental Heating Apparatus.*

fall towards the boiler is much more important than the manner of laying the pipes.

In the winter of 1893-4 a third series of tests was made. There were two objects in view: to again compare water and steam, and to determine the effect of different pressures upon the water system, by using high and low expansion tanks. The house and heater were the same as those used in the second test (Bulletin 55),—a lean-to lettuce house 16x27 ft., and a Novelty Hot Water

Circulator furnished by the Model Heating Co., Philadelphia. Fig. 67 shows the apparatus set up. Three $1\frac{1}{4}$ -inch risers or flow pipes run just under the roof, all uniting into one return. A delicate thermometer was let into each riser at the farther end (Nos. 2, 3, 4), and one into the return (No. 5) near the heater. Another was inserted in the riser (No. 1) just above the heater. These recorded the inside temperatures of the runs, for the naked bulbs were let into the very centers of the pipes. Two expansion tanks were provided, one (A) ten feet above the top of the heater, and another (B) twenty feet above it. Either one or both of these could be shut off by means of a valve. The heater is designed for water and the pipes were laid for water, being higher at the farther end. When the apparatus was used for steam, the water was simply lowered in the heater reservoir so as to make room for evaporation, and the piece of 4-inch pipe which led out of the top of the heater served for a steam dome. Of course the expansion tanks were shut off when steam was running. The advantages, therefore, were again in favor of the water system, but all our former conclusions respecting the superiority of steam over water, for the conditions given, were reaffirmed.

The following tables give the detailed results of the various tests :

A. WATER.—LOW EXPANSION TANK.

Observations.	Outside temperature.	House temperature.	Therm. No. 1.	Therm. No. 2.	Therm. No. 3.	Therm. No. 4.	Therm. No. 5.	Avg. therm. readings.
Dec. 9, 10:00 P. M.	38	54	212	65	150	—	170	149
Dec. 10, 10:45 A. M.	38	56	180	—	155	—	162	165
Dec. 10, 5:30 P. M.	32	54	180	—	163	—	157	166
Dec. 11, 7:45 A. M.	18	44	207	182	170	—	175	183
Dec. 11, 5:30 P. M.	20	54	205	182	120	—	110	154
Dec. 12, 7:30 A. M.	38	50	135	122	120	—	116	123
Dec. 12, 5:00 P. M.	20	50	210	193	171	—	175	187
Dec. 13, 8:00 A. M.	10	46	202	186	173	—	170	182
Dec. 13, 5:30 P. M.	9	44	195	175	169	—	166	176
Dec. 14, 7:30 A. M.	12	50	193	160	163	—	164	170
Dec. 14, 6:00 P. M.	21	46	214	190	194	—	190	197
Dec. 15, 8:30 A. M.	32	50	195	162	167	—	163	171
Dec. 15, 5:00 P. M.	45	56	150	130	133	132	135	136
Dec. 16, 8:00 A. M.	50	60	188	169	150	161	155	164
Averages	27	51	190	159	157	146	157	

A. WATER.—LOW EXPANSION TANK.—CONTINUED.

Observations.	Outside temp.	House temp.	Therm. No. 1.	Therm. No. 2.	Therm. No. 3.	Therm. No. 4.	Therm. No. 5.	Avg. therm.
Dec. 17, 5:00 P.M.	28	49	165	150	145	155	141	151
Dec. 18, 7:45 A.M.	20	48	170	147	140	162	116	147
Dec. 18, 5:00 P.M.	30	60	190	170	175	165	165	175
Dec. 19, 7:45 A.M.	34	50	200	180	185	165	170	180
Dec. 19, 5:00 P.M.	30	50	212	195	182	179	173	188
Dec. 20, 8:00 A.M.	14	42	175	153	138	143	140	149
Dec. 20, 5:00 P.M.	20	56	214	194	176	197	183	192
Dec. 21, 9:00 A.M.	32	58	203	183	186	170	173	182
Dec. 21, 5:00 P.M.	40	58	185	170	173	159	160	169
Dec. 22, 8:00 A.M.	36	52	145	125	135	125	123	130
Averages	28	52	185	166	163	162	154	
Jan. 25, 8:00 A.M.	19	58	214	187	190	194	186	194
Jan. 25, 5:00 P.M.	16	56	205	160	179	170	168	176
Jan. 26, 8:00 A.M.	9	48	189	170	172	161	160	170
Jan. 26, 5:00 P.M.	26	54	196	177	177	168	167	177
Jan. 27, 9:00 A.M.	24	58	212	195	185	180	181	190
Jan. 27, 5:00 P.M.	30	58	180	160	161	150	152	160
Jan. 28, 10:00 A.M.	28	68	214	169	190	180	187	188
Jan. 28, 5:00 P.M.	35	60	208	140	189	179	179	179
Jan. 29, 10:00 A.M.	30	60	208	184	193	198	182	193
Jan. 29, 5:00 P.M.	36	58	195	173	173	180	170	178
Jan. 30, 8:00 A.M.	26	54	197	178	178	182	170	181
Jan. 30, 5:00 P.M.	30	60	215	183	208	205	197	201
Jan. 31, 8:00 A.M.	30	60	195	167	183	164	169	175
Feb. 1, 8:00 A.M.	24	60	0	166	163	180	185	173
Feb. 1, 5:00 P.M.	24	60	208	153	190	164	166	182
Feb. 2, 8:00 A.M.	18	54	190	142	160	165	162	163
Feb. 2, 5:00 P.M.	28	58	190	166	165	158	157	167
Feb. 3, 8:00 A.M.	20	56	170	157	155	149	143	154
Feb. 5, 8:00 A.M.	10	54	210	193	180	179	172	186
Feb. 5, 5:00 P.M.	22	58	200	173	176	172	160	176
Feb. 6, 8:00 A.M.	15	48	190	167	162	157	160	167
Feb. 6, 5:00 P.M.	32	60	195	168	165	160	161	169
Feb. 7, 8:00 A.M.	29	54	212	187	178	174	177	185
Feb. 7, 5:00 P.M.	40	62	190	169	165	162	162	169
Feb. 9, 8:00 A.M.	32	54	200	180	180	170	170	180
Feb. 9, 5:00 P.M.	38	58	201	179	182	174	174	182
Averages	25	57	199	170	176	173	169	

B. WATER.—HIGH EXPANSION TANK.

Observation.	Outside temp.	House temp.	Therm. No. 1.	Therm. No. 2.	Therm. No. 3.	Therm. No. 4.	Therm. No. 5.	Avg. therm.
Dec. 16, 5:00 P.M.	44	63	208	189	180	195	183	191
Dec. 17, 7:00 A.M.	28	52	180	162	152	165	155	162
Averages	36	57	194	175	166	180	169	
Dec. 22, 5:00 P.M.	41	58	203	180	182	168	170	180
Dec. 23, 8:30 A.M.	48	61	205	181	180	191	172	185
Dec. 23, 5:00 P.M.	50	62	183	166	160	170	157	167
Averages	46	60	197	175	174	176	166	
Jan. 15, 5:00 P.M.	46	62	214	199	171	186	189	193
Jan. 16, 8:00 A.M.	44	60	208	198	196	187	182	194
Jan. 16, 5:00 P.M.	34	61	212	130	181	168	182	174
Jan. 17, 8:00 A.M.	30	58	190	121	170	175	164	164
Jan. 17, 5:00 P.M.	34	60	207	160	180	194	178	183
Jan. 18, 8:00 A.M.	32	50	204	182	170	190	176	184
Jan. 18, 5:00 P.M.	38	58	195	176	175	181	170	179
Jan. 19, 8:00 A.M.	30	58	215	192	200	206	195	201
Jan. 19, 5:00 P.M.	36	58	214	194	201	206	190	201
Averages	36	58	207	172	182	188	180	

C. STEAM.

Observation.	Steam pres. lbs.	Outside tem- pera- ture.	House tem- pera- ture.	Ther. No. 1.	Ther. No. 2.	Ther. No. 3.	Ther. No. 4.	Ther. No. 5.	Avg. ther. read- ings.
Dec. 26, 5 P. M.	0	18	60	208	185	190	195	187	193
Dec. 27, 8 A. M.	0	18	46	210	207	208	208	169	200
Dec. 27, 5 P. M.	2	30	60	220	217	219	219	179	210
Dec. 28, 8 A. M.	1½	34	54	219	215	216	218	168	207
Dec. 28, 5 P. M.	0	44	62	208	197	198	207	180	198
Dec. 29, 9 A. M.	1	40	62	214	211	212	214	183	206
Dec. 29, 5 P. M.	0	34	60	213	209	210	212	176	204
Dec. 30, 8 A. M.	1	24	62	215	211	212	214	185	207
Dec. 30, 5 P. M.	3½	24	62	224	222	223	223	177	213
Jan. 2, 8 A. M.	2	29	58	230	230	229	229	190	221
Jan. 3, 8 A. M.	0	38	60	212	208	210	212	180	204
Jan. 4, 7:30 A. M.	0	42	54	207	—	65	56	180	127
Jan. 4, 5 P. M.	0	62	70	213	212	208	212	184	204
Jan. 5, 8:45 A. M.	0	40	62	212	192	206	196	176	196
Jan. 5, 5 P. M.	0	32	59	215	185	215	210	178	200
Jan. 6, 8 A. M.	0	28	59	208	—	145	205	179	184
Jan. 6, 5 P. M.	0	31	56	210	208	205	209	180	202
Jan. 7, 9 A. M.	0	30	60	202	110	108	110	84	122
Jan. 8, 8 A. M.	0	31	52	213	180	207	212	180	198
Jan. 8, 5 P. M.	½	28	60	212	198	209	211	158	197
Jan. 9, 8 A. M.	1	18	56	216	200	211	215	170	202
Jan. 9, 5 P. M.	½	26	58	214	201	211	212	168	201
Jan. 10, 8 A. M.	0	26	50	208	180	195	206	178	193
Jan. 10, 5 P. M.	0	31	52	207	85	87	89	168	127
Jan. 11, 8 A. M.	0	29	54	211	186	206	211	179	198
Jan. 11, 5 P. M.	0	38	60	208	160	195	205	178	189
Jan. 12, 8:30 P. M.	0	18	53	212	203	208	211	180	202
Jan. 12, 5 P. M.	2½	18	54	222	211	216	220	180	209
Jan. 13, 8 A. M.	0	16	60	212	200	209	211	172	203
Jan. 13, 5 P. M.	0	28	62	214	205	210	210	178	203
Jan. 14, 9:50 A. M.	0	44	60	205	198	202	204	168	195
Jan. 14, 5 P. M.	1½	50	70	215	214	210	212	180	206
Jan. 15, 8 A. M.	0	40	64	214	203	210	213	181	205
Averages.....		31	55	212	194	195	199	174	

It will be seen from table A that three distinct tests, of various duration, were made with the low tank or low pressure, and from B that three short tests were made with high pressure. In drawing conclusions from all the tables, the temperatures of the house should be discarded, and the efficiency of the different trials should be deducted from the temperatures of the pipes as shown by thermometers 1, 2, 3, 4 and 5. This is because the temperature of the house was kept as uniform as possible by ventilation, so

that as the heat rose in the pipes, when steam or water under greater pressure was used, the ventilators were opened wider.

By making a general total average of the various pipe temperatures in the three systems, A, B, and C, we have the following figures :

D. SUMMARY OF THE AVERAGE TEMPERATURES IN THE VARIOUS THERMOMETERS.

Water, Low Tank.

	1.	2.	3.	4.	5.
Test 1.....	190	159	157	146	157
Test 2.....	185	166	163	162	154
Test 3.....	189	152	150	163	155
Test 4.....	199	170	176	173	169
Average.....	191°	162°	161°	161°	159°

Water, High Tank.

Test 1	194	175	166	180	169
Test 2.....	197	175	174	176	166
Test 3.....	207	172	182	188	180
Average.....	199°	174°	174°	181°	172°

Steam.

212°	194°	195°	199°	174°
------	------	------	------	------

It is seen at once that the lowest average efficiency is in the lower pressure water system, the next best is with the high tank, while the highest is with steam. That is, the higher the expansion tank above the heater, within reasonable limits, the hotter the water becomes because it is under greater pressure. This increase of heat was observed in all parts of the system, as shown by the uniformly higher averages in the five several thermometers. The system was also more easy to run, the circulation was more uniform in all the pipes, and its generally efficiency was seen to be greater by the workmen who had charge of it. With the greater elasticity and less friction of steam, however, the efficiency is still greater, as shown in the summary figures (D). From these considerations we conclude that

10. *In heating by water in closed circuits, a high expansion tank may increase the efficiency by allowing the water to become hotter throughout the system, and giving a better circulation.*

If we were to compare the fluctuations, or up and down temperatures, in the various systems, by a study of the average ther-

mometer readings in all the pipes—as shown in the last column in the tables—we should find the following :

E. EXTREME AVERAGE FLUCTUATIONS.

Water, low tank	123°	201°
Water, high tank	162°	201°
Steam	122°	221°

The steadiest temperature was maintained in the water under the greater pressure, whilst the greatest fluctuations were with steam. This poor showing of the steam, however, is mostly the result of the unadaptability of the apparatus to steam heating. In our first tests, the fluctuations were greater with water, whilst in the second, when this small heater was used, they were about the same with steam and water.

Now, the total warming power of the different systems is determined by the average temperatures of the pipes and the amount of fuel consumed. In this test we used 100 lbs. of hard coal daily in each of the three series of tests ; and inasmuch as this fuel gave more heat when applied to steam than when applied to water in the same apparatus, we must conclude that under these conditions, now repeated for two winters and with the initial advantage in favor of water, steam was the more efficient and economical. If, however, more piping had been added when water was used, the final results might have been in favor of water, particularly of the greater pressure.

Illuminating gas as fuel.—Common illuminating gas is much used for fuel in small stoves, water heaters, and the like. It seemed that it might be used to advantage in heating small conservatories attached to dwellings, because it is difficult to secure a very small circulator which has a fire-pot big enough to hold a bright fire all night. I accordingly put a Perfection Water Heater (made by the Milwaukee Gas Stove Co.) in my cellar to heat a small conservatory which is 10x17 and 12 feet high. This was connected with the city gas system. Including the connections in the cellar (40 ft.), this little heater was expected to heat 220 linear feet of inch pipe with hot water. A steam heater is not practicable for such a small area.

The gas was first lighted one December day when the pipes were cold. An hour was required to thoroughly warm up the

system. In ordinary snug winter weather (thermometer outside 10° to 15°), the apparatus consumed one-half cubic foot of gas per minute to keep the house at a proper temperature for conservatory plants. The system worked perfectly. Not one thing more could be desired,—except cheaper gas. A very slight increase in the amount of gas—supplied by simply turning a valve—was sufficient to make a very rapid change in the temperatures of the pipes, so perfectly was the system under the control of the heater. So long as the weather was running nearly uniform, the heater demanded no thought or attention. It is the perfection of a lazy man's machine. The readiness with which the system responded to more or less gas may be indicated by the following test. When the experiment began, the apparatus was consuming one cubic foot of gas every $2\frac{3}{4}$ minutes. Thermometer No. 1, on the outside of the riser at its highest point 58 ft. from the heater, registered 94° and thermometer No. 2, on a return 70 ft. from the heater, registered 68° . Gas was turned on until a cubic foot was consumed every $1\frac{1}{2}$ min. The temperatures went up as follows :—

	Thermometer 1.	Thermometer 2.
7 min. later.	95°	68° .
10 "	98	68
14 "	100	68
20 "	101	70
25 "	103	72
31 "	105	74
40 "	106	76
45 "	108	77
60 "	110	79
75 "	111	80
85 "	112	80
97 "	113	80

The average gas consumption for the few days of the test, as charged by the gas company, was 650 cubic feet per day. At the price we paid for gas, the expense of running the heater was prohibitive, and it was given up with much reluctance.

LETTUCE.

Lettuce is the most popular and the most uniformly profitable of all vegetable crops grown under glass in this country. It grows rapidly, so that three crops can be taken from a house between September and April, and the demand for a choice product is always good. Lettuce is generally considered to be an easy crop to grow under glass, and yet it is a fact that few gardeners are entirely successful with the crop, year by year, particularly if the heading varieties are grown.

Lettuce varies greatly in quality, and this variation is due in very great measure to the immediate conditions under which it is grown. If the plant is very rank and has dark green thick leaves, the quality is low. A good lettuce plant is yellowish green in color upon delivery, and the leaves are thin and brittle. The product should be wholly free from lice, or green-fly, and the tips of the leaves should show no tendency to wither or to turn brown. If heading lettuce is grown, the leaves should roll inward like cabbage leaves, the heads should be compact and nearly globular and yellowish white towards the core.

It is not my purpose to enter into a full account of lettuce forcing at this time; I desire only to suggest a few of the most important points in the cultivation of the crop, as they have presented themselves to me during the past few years.

In the first place, lettuce must have a low temperature. The night temperature should not rise above 45° , while it may go as low as 40° , or even lower. The day temperature, in the shade, should be 55° to 65° . Lettuce which is kept too warm grows too tall, and the leaves are thin and flabby; and there is generally more danger of injury from aphid, rot and leaf-burn.

Whilst a lettuce house must have an abundance of light, the plants do not suffer if they are some distance from the glass and even if they receive little direct sunlight. The house should have an exposure towards the sun and the framework ought to be as light as possible, if the best results are to be obtained; but diffused light is quite as good as the direct burning rays of the sun.

It should be said, however, that good lettuce may often be grown in heavy rather dark houses, but more care is required, the results are less certain, and there is special difficulty in growing the heading varieties to perfection.

Our own experience has fully demonstrated the superiority of solid earth beds over benches, for lettuce. We have had good



68.—A ground bed, with *Grand Rapids* lettuce.

crops in benches, but they have required special attention to heating and watering, and even then the results are generally precarious. If, however, the benches have no bottom heat—that is, if there are no heating pipes close under them and if the sides are open—very good results, particularly with the non-heading sorts,

may be had from year to year. Fig. 68 shows an earth bed, about nine inches deep, in which we have had excellent success with lettuce.

When pressed for room, we sometimes prick off the plants into 3-inch or 4-inch pots and set these pots in unoccupied places amongst other plants. Very good lettuce can be grown in this way, although it is scarcely practicable in commercial houses.

Probably no forced vegetable is so much influenced by soil as the lettuce, and no doubt more failures are to be ascribed to uncongenial soil than to any other single cause. Fortunately this matter has been made the subject of a most admirable study by Galloway,* who finds that the famous heading lettuce of the Boston gardeners can be grown to perfection only in soils which contain much sand and very little clay and silt. These soils allow the water to settle deeply into it and yet holds it without percolation; the surface is dry, preventing the occurrence of rot; the roots forage far and wide, and the plant food is quickly available. The full characters of the soil used by the Boston growers are set forth as follows by Galloway: "Loose at all times, regardless of treatment, it being possible to push the arm into it to a depth of 20 inches or more. Never 'puddles' when worked, no matter how wet. Clods or lumps never form. A 4-inch dressing of fresh manure when spaded in to a depth of 15 to 20 inches will be completely disintegrated in six or eight weeks. Sufficient water may be added the first of September, when the first crop is started, to carry through two crops and a part of a third without additional applications, except very light ones merely to keep the leaves moist and to induce a movement of the moisture at the bottom of the bed toward the top, where it will come in contact with most of the roots. The surface to a depth of an inch dries out quickly, and this has an important bearing on the prevention of wet rot of the lower leaves. The active working roots of the plants are found in abundance throughout the entire depth of soil, even if this exceeds 30 inches."

Galloway was able to prepare soil which "gave practically the

* B. T. Galloway, "The Growth of Lettuce as Affected by the Physical Properties of the Soil," *Agric. Science*, viii. 302 (1894).

same results" as that which he imported from Boston. This soil was made as follows: "Mixture of two parts of drift sand and one part of greenhouse soil. The sand was obtained from the valley of a stream near by, which frequently overflowed its banks, flooding the spot where the material was found. The greenhouse soil was a mixture consisting of one part of the ordinary clay, gneiss soil of the region, and two parts of well rotted manure. Such soil will grow 20 bushels of wheat to the acre without fertilization."

It is always essential to the best lettuce growing to avoid "heavy" soils. These soils usually lose their water quickly, necessitating frequent watering which keeps the surface wet and increases danger from damping-off and rot. These soils soon become hard, compact and "dead," and the plants grow slowly, with thick tough leaves.

If the lettuce crop is to be taken off in early November, from seven to ten weeks should be counted from the sowing of the seeds to the delivery of the product. A midwinter crop may require two to four weeks longer. The time may be shortened ten days to two weeks by the use of the electric arc light hung directly above the house. A single ordinary street lamp of 2,000 normal candle-power, will be sufficient for a house twenty feet or more wide and seventy-five feet long, if it is so hung that the house is uniformly lighted throughout. Our experiments with the electric light, now extended over a period of five years, have uniformly and unequivocally given these beneficial results with lettuce.*

The first sowing for house lettuce is usually made about the first of September and the crop should be off in November. We sow the seeds in flats or shallow boxes, preferably prick off the young plants about four inches apart into other flats when they are about two weeks old, and transplant them into the beds, about eight to ten inches apart each way, when they are about five weeks from the seed. We often omit the pricking off into other flats simply thinning out the plants where they stand and transferring them from the original flat directly to the bed; but better and

* See our bulletins 30, 42 and 55.



99.—*Landreth Forcing lettuce, two-thirds grown.*

quicker results are usually secured if the extra handling is given. Four or six weeks after the first seed is sown another sowing is made in flats for the purpose of taking the place of the first crop. Following are some actual sample dates of good and bad lettuce growing in our houses, in a climate which is unusually cloudy and "slow" in winter: Landreth Forcing lettuce sown in flats February 24th; transplanted to beds, March 17th; first heads marketed, under normal conditions, May 10th; first heads marketed from a compartment receiving electric light at night (a total of 84 hours), April 30th, or 44 days from seed. Simpson curled was sown October 3rd. November 7th, transplanted to bed. It was desired to hold the crop back, so that the house was kept very cold; and the variety is not well adapted to quick forcing, so that it was January 30th, before the entire crop was fit for market, making 119 days from seed. Grand Rapids

lettuce sown December 28th ; transplanted to bed, January 16th ; began marketing March 21st. This makes 72 days from seed, in the dark months ; and at least a week could have been gained if we had not been obliged to delay transplanting whilst waiting for a crop of chrysanthemums to come off the bed.

The varieties of forcing lettuce are many, but the leading ones at present are the Boston Market or White-Seeded Tennis Ball, and Grand Rapids. The former is the famous heading lettuce of eastern markets. It is usually a difficult variety to grow to perfection unless the soil and conditions are well adapted to it. Another excellent lettuce of this type is Landreth Forcing, shown two-thirds grown in Fig. 69. The Grand Rapids is a loose-leaved lettuce, shown full grown in Fig. 68. It grows rapidly and is of very easy cultivation.

The most inveterate pest of the lettuce grower is the green-fly or aphid. If it once gets thoroughly established, the most strenuous efforts are needed to dislodge it. The pest is most frequent in houses that are kept too warm. The plants may be sprinkled with tobacco dust, or tobacco stems may be strewn upon the ground between the plants and in the walks, and either treatment may be expected to keep down the aphid. It can easily be kept out of the houses by fumigating *twice a week* with tobacco. (See page 329). *Do not wait until the insect appears.* Begin fumigating as soon as the plants are first pricked off and continue until within two or three weeks of harvest, or longer if necessary.

The rot often ruins crops of lettuce. The outer leaves decay, often quickly, and fall flat upon the ground, leaving the central core of the plant standing. Fig. 70 is a fair sample of a whole bench of lettuce which we lost a few years ago from the rot. The plants were about two-thirds grown and in good condition. The house was rather over-piped for lettuce and we kept it cool by careful attention to ventilation. It became necessary for the assistant horticulturist and myself to be absent three days in mid-winter. Careful instructions were given a workman concerning the management of the house, but he kept it too close and too wet and at the end of the three days the crop was past recovery.

This lettuce rot is due to a fungus (*Botrytis vulgaris*) which lives upon decaying matter on the soil, but when the house is kept

too warm and damp, and the lettuce becomes flabby, it invades the plant and causes irreparable ruin. There is no remedy, but if the soil is sandy and "sweet" and the house properly managed as to moisture and temperature, and top dressings of manure are avoided, the disease need not be feared. Galloway speaks of it as follows, in the article already quoted: "Wet rot of the lower leaves and rotting of the stems and consequent wilting of the plant are seldom troublesome in this [Boston or sandy] soil if properly handled, because the surface is at all times comparatively dry. Wet rot is produced by a fungus which may be found at any time



70.—Lettuce plant collapsed by the rot (*Botrytis vulgaris*).

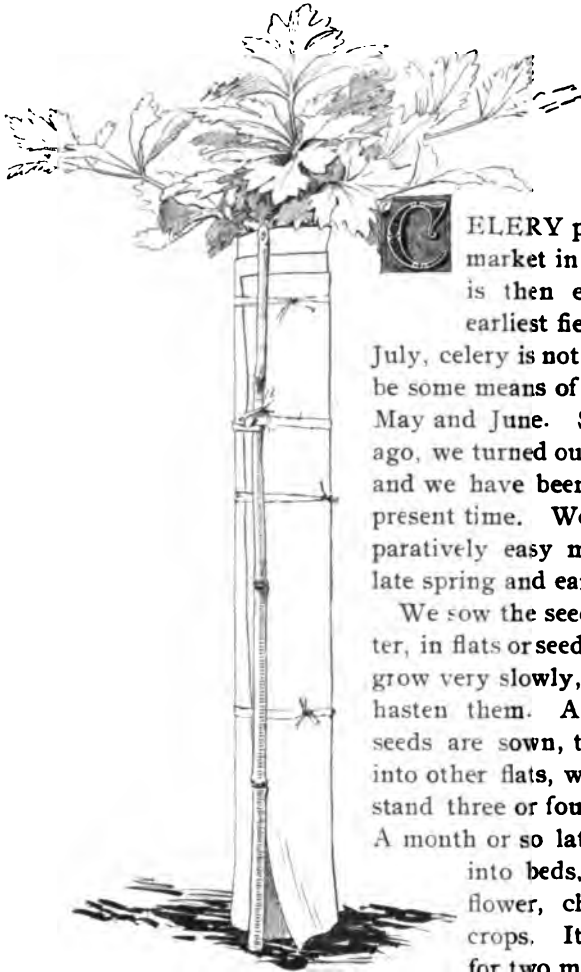
on pieces of sticks and straws scattered through the soil. The fungus does not have the power of breaking down the uninjured tissues of the plant, excepting possibly in very rare cases. When the tissues become water-soaked, however, as they do when in contact with wet soil, the fungus, which is also most active in the presence of moisture, readily gains entrance and soon develops sufficient energy to become an active parasite."

The mildew (*Peronospora gangliiformis*) is the staple lettuce disease of the books, but we have never had experience with it. No doubt much of the trouble ascribed to mildew is really the rot.

Leaf-burn is a dying of the tips of the leaves when the plant is nearly or quite mature. It is particularly troublesome on the heading varieties, in which the slightest blemish upon the leaves detracts greatly from the selling qualities of the lettuce. This

difficulty, according to Galloway, is attributable largely to the soil: "Top burn, one of the worst troubles of the lettuce grower, does comparatively little injury on this Boston soil, providing the proper attention is given to ventilation and the management of the water and heat. Burn is the direct result of the collapse and death of the cells composing the edges of the leaves. It is most likely to occur just as the plant begins to head and may be induced by a number of causes. The trouble is most likely to result on a bright day following several days of cloudy, wet weather. During cloudy weather in winter the air in a greenhouse is practically saturated, and in consequence there is comparatively little transpiration on the part of the leaves. The cells, therefore, become excessively turgid and are probably weakened by the presence of organic acids. When the sun suddenly appears, as it often does after a cloudy spell in winter, there is an immediate, rapid rise in temperature and a diminution of the amount of moisture in the air in the greenhouse. Under these conditions the plant rapidly gives off water and if the loss is greater than the roots can supply the tissues first wilt, then collapse and die. The ability of the roots to supply the moisture is affected by the temperature of the soil, the movement of water in the latter, and the presence or absence of salts in solution. In this soil the temperature rises rapidly as soon as the air in the greenhouse becomes warm, and the roots in consequence immediately begin the work of supplying the leaves with water. The movement of the water in the soil is also rapid, so that the plant is able to utilize it rapidly."

CELERY UNDER GLASS.



CELERY practically goes out of the market in April. The stored crop is then exhausted, and until the earliest field product is received, in July, celery is not to be had. There should be some means of supplying the demand in May and June. Some three or four years ago, we turned our attention to this problem and we have been working at it until the present time. We now feel that it is a comparatively easy matter to grow celery for late spring and early summer use.

We sow the seed in late fall or early winter, in flats or seed-pans. The young plants grow very slowly, and we make no effort to hasten them. About a month after the seeds are sown, the plants are pricked out into other flats, where they are allowed to stand three or four inches apart each way. A month or so later, they are transplanted

into beds, following lettuce, cauliflower, chrysanthemums or other crops. It will thus be seen that

71. *Winter-grown celery a-bleaching.*

for two months or more the plants take up little or no room, for the flats are placed in vacant places here and there throughout the house; and they need little other care than watering. They should be kept cool,—in a house used for lettuce, violets, carnations, and the like,—for if one attempts to force them they will likely run to seed. When the plants are finally transplanted, we like to put them in solid beds without bottom heat.

In six weeks to two months after the plants are turned into

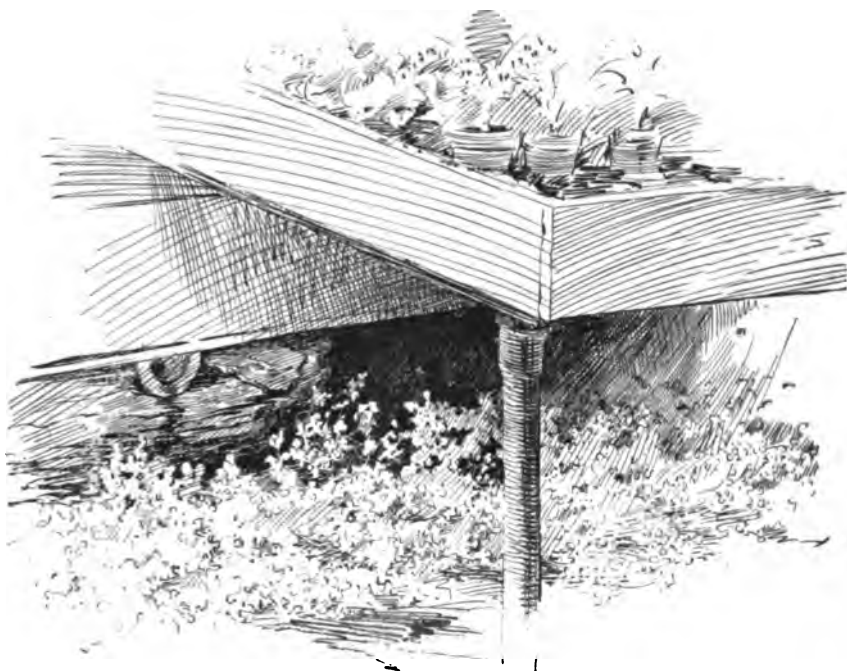
their permanent quarters, they will be ready to bleach, and this operation has caused us more trouble than all other difficulties combined. Our first thought was to set the plants very close together so that they would bleach themselves, after the manner of the "New Celery Culture," but it would not work. The plants ran too much to foliage and they tended to damp-off or rot where they were too close. We next tried darkening the house, but without success. We then attempted to bleach the plants by partially burying them in sand in a cellar, but this also failed. Finally, we tried various methods of tying up or enclosing each midwinter plant as it stood in the bed. Tiles placed about the plants—which are so successful in the field,—rotted the plants in the moist air of the forcing-house. Heavy bibulous paper did the same. But thick, hard wrapping paper, with an almost "sized" surface, proved to be an admirable success. The stalks were brought together and tied, and a width of paper reaching to within two or three inches of the tips of the leaves, was rolled tightly about the plant. As the plant grew, another width of paper was rolled about the first, and again reaching nearly the top of the plant. Two applications of the paper are sufficient. A month to six weeks is required to bleach the celery by this process in a cool house in April and May. Fig 71 shows the method of bleaching with the paper.

The seeds for our last crop of house celery were sown December 10th, 1894; pricked off January 8th; planted in beds, February 6th; first tied up in paper, April 12th; second tying, May 9th; celery fit to use, May 21st to June 20th. The Kalamazoo celery is well adapted to house cultivation. The quality of this house-grown product is equal to that grown in the field.

CRESS IN WINTER.

Persons who are fond of water-cress should know that no plant is easier to grow under benches in greenhouses. If there is an earth floor under the benches of a cool or intermediate house, the plant will take care of itself when once introduced, provided of course, there is sufficient moisture. Fig. 72 shows a mat of water-

cress growing under a bench in a general conservatory house, near the overflow of a tank. It is not necessary to supply water in which the plant may grow, but it thrives well, with its characteristic flavor, in soil which is simply uniformly moist and cool. The plants may be gathered from brooks or other places where it



72.—*Water-cress under a greenhouse bench.*

is established and planted at intervals under either north or south benches, and when once colonized it needs no renewing.

The ordinary French or garden cress (varieties of *Lepidium sativum*), also thrives well under glass. We have grown both the plain and curled-leaved forms upon benches or beds along with lettuce and spinage. The seed is sown directly where the plants are to stand. The plant grows quickly and the early tender leaves should be used before it runs to seed.

FORCING EGG-PLANTS*.

The possibility of forcing egg-plants successfully was suggested by a crop which was grown under glass in one of the market gardens near Boston, in the spring of 1891. These plants were not grown with the intention of forcing them ; but as the greenhouse was vacant at the time the main crop of egg-plants was set out of doors, it was filled with plants taken from the same lot as those set in the open. The beds in which they were planted were solid, that is, the prepared soil rested upon the natural surface of the ground, forming a layer from twelve to fifteen inches in depth. During the preceding winter those beds had served for growing lettuce and they had consequently been well enriched with stable manure, a fertilizer which is especially effective in the production of rapid growth. In July, when the plants grown under glass were compared with those planted in the open ground, an astonishing difference could be observed. Those set in the house were fully twice as large as the others ; the leaves were larger and the stems thicker than those generally found in the gardens of this latitude, and the abundance of healthy foliage was ample proof that the plants were subjected to conditions extremely favorable to their growth.

Another interesting point was soon noticed. Although the plants were blossoming quite freely, still comparatively little fruit had set, and it appeared as if the entire energies of the plants had been directed towards the production of foliage at the expense of the fruit. This condition may perhaps be ascribed to two causes. Extreme activity of the vegetative functions of plants is frequently carried on at the expense of fruit production ; this fact is commonly illustrated by young fruit trees which blossom sometimes several years before they set fruit. The growth of the egg-plants mentioned above was sufficiently luxuriant to suggest the possibility of its having some effect upon the fruiting powers of the plants. The second and perhaps most probable cause of this unsatisfactory fruiting may have been imperfect pollination. Insects, and especially bees, were not working so freely in the house as outside, and later experience has shown very clearly that in

*Bulletin 26 contains an account of egg-plants in the field.

order to get a satisfactory crop from egg-plants grown under glass thorough pollination must be practiced. The foliage was so dense that the flowers were for the most part hidden. In such a position they were necessarily surrounded by a comparatively damp atmosphere, especially when borne upon branches that were near the surface of the soil, and this would still further tend to interfere with the free transfer of pollen by any natural agencies. Under such conditions a profitable yield could scarcely be expected; yet when carefully observed the plants proved to be so full of suggestions regarding the proper methods of treating them that they should have repaid the time given to their culture by a plentiful harvest of ideas, if not of fruits.

Acting on the above hints several attempts have been made to grow egg-plants in our forcing houses, with the object, however, of fruiting them out of season. The first lot of seed was sown August 30, 1893. It embraced the following varieties: Black Pekin, New York Improved, Early Dwarf Purple, Round Purple, and Long White. The seed was sown about three-eighths of an inch deep in rich potting soil. The flats, or shallow boxes, which contained the seed were placed in a warm house, and the after treatment was very similar to that commonly followed in the growing of tomatoes.

The seedlings required pricking out about four weeks after the seed was sown. They were set in $2\frac{1}{2}$ inch pots where they remained until November 14th, when they were shifted into 4-in. pots. On December 17th, or nearly sixteen weeks from the time of seed sowing, the plants had filled these pots with roots, and they were again shifted, but this time into benches. They were set 2 feet apart each way. The soil was about 6 inches deep and different in character in each of the two benches used. One bench had been filled with a mixture of equal parts of potting soil and manure from a spent mushroom bed. This formed a very open and rich soil which appeared to be capable of producing a strong growth. The second bench received a rich, sandy loam which had previously been composted with about one-fourth its bulk of stable manure. The temperature of the house was that usually maintained in growing plants requiring a considerable amount of heat; during the night the mercury fell to 65° or 60° and in

the day time it stood at 70° - 75° . In the bright weather the house was still warmer.

Considerable care was exercised in watering the plants, the soil being kept somewhat dry ; when grown out of doors egg-plants withstand drought so well that such a course seemed advisable



73.—*Early Dwarf Purple Egg-plant under glass.*

when growing them under glass. As the plants increased in size the leaves shaded the soil, and an occasional thorough watering maintained an excellent condition of moisture in the bed filled with the loam. In addition, the soil was stirred with a hand weeder when necessary.

For some time, all the varieties in each bench appeared to be doing uniformly well, but the plants set in the sandy loam made a stronger growth and appeared to be more vigorous. This was

especially noticeable in the Early Dwarf Purple and the New York Improved. The first bloom appeared on the former during the last week in December, and on the 3d of January, 1894, several plants showed flowers that were well opened. These were hand pollinated and they set fruit freely. On February 15th some of these fruits were $2\frac{1}{2}$ inches long, the plants still growing well and producing many blossoms. It was at this time that the first flowers of Black Pekin appeared, but New York Improved had not yet produced any, although it was making a strong growth. Round Purple and Long White were making a very slow and weak growth.

Figure 73 represents a plant of Early Dwarf Purple that was photographed May 29th. It was bearing at this time 21 fruits of varying sizes and appeared to be strong enough to mature fruits from buds that were still forming. The larger fruits were fully 4 inches in diameter, and nearly 6 inches long. They were not removed as soon as grown, as should be done in order to get as large a yield as possible, and for this reason the product of the plant is the more remarkable. All the fruits did not attain the size mentioned above for the crop was too heavy for the plant to mature it properly; neither were all the plants of this variety equally prolific, although their yield in many cases closely approached that shown in the illustration. This variety proved to be by far the most promising of those grown for forcing purposes, and it appears to be capable of producing crops which rival those grown out of doors. It is also the earliest variety tested, a point which is of the greatest importance. This vegetable is slow in coming to maturity even under the most favorable circumstances. The above photograph was taken nine months from the time of sowing the seed, but a cutting of fruit might have been made fully six weeks earlier. It set fruit more freely than any other variety, and in nearly every desirable respect was superior to them.

New York Improved was a very strong grower, and produced large handsome fruits. Unfortunately, but few could be obtained from a plant, and the total yield was therefore comparatively small, only four or five maturing on the best plants. It is also considerably later than the Early Dwarf Purple.

Black Pekin, on the whole, closely resembled the preceding,

especially in the manner of its growth. But it set scarcely any fruit, and that was so late that none were matured before ten months from the time of seed-sowing.

Long White proved to be a weak grower of very slender habit. It was also very late, the fruits being scarcely over two inches in length May 29th. The plants of this variety were slightly checked when young, and this may have had a certain influence in delaying the maturity of the crop, although the effect was probably not very great. One desirable feature of this variety is its smooth foliage which appeared to be unfavorable for the development and persistence of some of the insects that attack greenhouse plants. But the lateness of the variety and the few fruits produced by it will prevent it from being profitably grown under glass.

Round Purple proved to be the most unsatisfactory grower. All the plants showed symptoms of being in unfavorable quarters, and the test with this variety resulted almost in total failure.

Later attempts to force egg-plants have been made, although no duplicate of the above experiment has been planned. The crops were started later in the season when more sunlight and heat were present. These trials have thrown light upon some of the doubtful points of former experiments, and have shown what is probably the principal reason of the slow maturing of all the varieties tested, and also the very weak growth of some.

One of the results obtained is of especial interest in this connection. Some Early Dwarf Purple plants were started early in August and some of the seedlings were grown in houses in which different degrees of temperature were maintained. The plants grown in an intermediate or moderately warm house made but little growth, and were soon stunted and worthless. This showed conclusively that egg-plants require a high temperature for their rapid and vigorous development. Other plants were placed in each of two warm houses, one of which was shaded by means of a thin coat of whitewash upon the glass. The plants in the other house were exposed to direct sunlight and they were also subjected to a bottom heat of scarcely five degrees. Although the air temperature of the two houses was practically identical, the plants receiving the sunlight grew fully twice as

fast as the others and had open blossoms before those in the shaded house showed any buds. When some of the latter were removed into the same favored position they very soon showed a benefit from the change. In this way the plants themselves emphasized the necessity of plenty of sunshine for their development in winter quarters; and a certain amount of bottom heat, from four to six degrees, is also very beneficial, the air temperature at the same time being that of a warm house.

Egg-plants designed for forcing should never be stunted. An important aid to prevent this condition is a soil which is open and still rich in available nitrogen. A rich, sandy loam in which all



74.—*Flower of Egg-plant.*

the ingredients are well rotted is preferable to one having the manure in an undecayed condition. The latter is too open, and it is more difficult to maintain a proper supply of moisture. The soil should be sufficiently open to afford good drainage, but not so coarse that it dries out too rapidly. The bench mentioned at the beginning of the article as containing manure from a spent mushroom bed did not prove so satisfactory as the one containing the sandy loam, largely because it was more difficult to manage.

Another point which should not be overlooked in forcing egg-plants is the pollination of the flowers. This is most satisfactorily done by hand, the small number of insects found in green-houses during the colder months being of very little use in this respect. The work can be done rapidly by means of a small flat, piece of metal such as can be made by flattening the point of a pin with a hammer and then inserting the other end into a small stick which will serve as a handle. Such a spatula is also very convenient in nearly all kinds of pollination made by hand, as it is so readily kept clean of foreign pollen. Figure 74 represents a flower of an egg-plant. In the center will be seen the stigma which projects beyond the tips of the ring of anthers or pollen

bearing organs which surround it. If an anther is separated and closely examined it will be seen that there are two small openings at the tip ; it is through these that the pollen normally escapes. But this escape does not take place freely until the flower has matured to such an extent that the tips of the anthers stand erect and recede from the stigma, leaving the latter standing unsupported. The pollen can be most rapidly gathered upon the spatula by inserting the point of the metal into the side of the anther and opening it by an upward movement of the instrument. In this manner a large quantity of pollen may be gathered very rapidly, and it is the work of but an instant to press it upon the end of the stigma. One such treatment, if performed when the surface of the stigma is adhesive, is sufficient for each blossom.

Egg-plants are subject to the attacks of all the common greenhouse pests, but if care is exercised from the beginning no serious damage need be feared. Green-fly is easily overcome by tobacco smoke as described on page 329, while mealy bug can be overcome by well directed streams of water. The foliage of egg-plants is not easily injured by such applications of water and the insects may be dislodged with impunity as often as they appear. The worst pests of egg-plant foliage are the red spider and his near relative, the mite. The latter is especially difficult to treat, as it is not so much affected by moisture as is the red spider, and for this reason it cannot be so readily overcome. The rough foliage of the egg-plant is especially well adapted to the lodgement of these mites, and when they have once become established their extermination is practically impossible. Too much care, therefore, cannot be taken in watching for the first appearance of these scourges, and in destroying them as soon as discovered. It is well to apply water freely to the foliage, even before the insects appear, for the leaves do not immediately show their presence and such applications will do no harm. The Long White does not suffer from these insects so much as the other varieties, since it has comparatively smooth leaves which do not afford a very secure retreat. Nevertheless it will bear watching as well as the others. The water that is applied should be directed mainly toward the under surface of the leaves, as the insects are here found in the greatest abundance, and the parts are also most difficult to reach.

The returns to be derived from egg-plants grown in green-houses cannot yet be estimated, since to my knowledge no such products have ever been placed upon the market. The first fruits from the south command a good price, but whether the home-grown article will meet with such favor that it will repay the cost of the long period of growth cannot be told. The experiment from a commercial standpoint is well worth trying.

WINTER PEAS.

During the past few years, peas have at various times been grown in the forcing houses at Cornell with the intention of determining their value as a commercial crop and also to study their behavior under glass. The forcing of peas has been carried on in northern Europe for many years, although on a somewhat different plan than that undertaken at this station. Foreign gardeners generally grow the winter crop in frames or hot-beds. In the neighborhood of Paris such protection is unnecessary and successive sowings are made in the open ground from November to March, one of the most popular varieties for this purpose being St. Catherine (*Pois de Sainte-Catherine*). This variety is particularly well adapted to late fall and early winter sowings. In more northern latitudes, either cold frames or hot-beds supply the necessary protection for maturing the crop. Ringleader, Early Dwarf Frame, and Caractacus have been very popular in England. The second named variety is especially adapted for growing in hot-beds. It is exceedingly dwarf and matures very quickly, so that considerable quantities of peas may be harvested from a small area. Taller varieties are generally bent over to admit of their proper growth.

Peas thrive in a cool temperature, and the protection afforded by comparatively little glass or wood is sufficient to carry them through moderately cold weather. In the northern states, artificial heat must be given if the crop is to be grown during the winter months. As this cannot be done conveniently in frames, larger structures must be employed, and these may easily be supplied with a proper amount of heat for growing this vegetable. A

night temperature of 40° to 50°, and a day temperature ten to twenty degrees higher, will be sufficient to cause rapid growth and fairly prolific plants. Peas succeed best, as a rule, if grown in solid beds of rich, sandy soil that is well supplied with water. If peas grown under glass are subjected to the above conditions, their culture presents no serious difficulties, and it will scarcely be necessary to mention the details of more than one crop which we have grown.

Seeds of two varieties of peas were sown January 6, 1894; they were Extra Early Market, and Rural New-Yorker. They were planted at the same depth as in out-door culture, but the seed was sown more thickly, and the rows were as close to each other as the after culture of the crop would allow. Very dwarf varieties, such as Tom Thumb and American Wonder, may be planted in rows 3 to 5 inches apart, depending on the richness of the soil and the general care given the plants. Tall growing varieties, as Champion of England, may be sown in rows running in pairs, the distance between the rows of each pair being from 6 to 10 inches, while the pairs are separated by spaces 15 to 18 inches wide. This will allow working-room among the plants and still admit of heavy planting.

One of the essential points in the successful growing of peas, whether in a greenhouse or out of doors, is the use of fresh seed. Garden peas retain their vitality from three to eight years, but the shorter period may be considered as more nearly correct when applied to varieties which are to be forced, since the loss of a week or two under glass is expensive, and two sowings cannot well be afforded. The seedlings began to appear eight days after seed sowing and they grew vigorously from the start. February 23d, Rural New-Yorker showed the first opened blossoms, Extra Early Market at the same time having buds which were about to open.

On the 20th of March, or about seventy-three days from sowing the seed, both varieties had matured sufficiently to supply pods that were fit for market, but no picking was made until eleven days later when the plants yielded pods at the rate of 6½ quarts for each 30 feet of double row. There was practically no difference between the two varieties as regards earliness or the amount of yield obtained. Two weeks later, a second and last picking

was made, the plants yielding only one-half as much as before. This brings the total yield to a little over a peck. This is scarcely a profitable crop, especially since the varieties grown are quite tall and required a trellis.

Formerly, the trellises used consisted of branches forced into the ground so that they would afford support to the vines. But with the crop here considered, a more satisfactory trellis was made by using a wire netting having large meshes. This was fastened between the rows by means of stakes, and thus each strip of netting served as a support for a double row. This forms the neatest and most substantial trellis here used for supporting the vines.

The yields from extremely dwarf varieties, such as Tom Thumb, have proved unsatisfactory. The plants require no support, but they yield only one picking and this is so light that their culture under glass cannot in all cases be advised.*

Peas grown under glass are sensitive to heat, and the warm spring days, when accompanied by sunshine, check their growth to a marked degree. The most healthy growth is made during the cold months of the year, and after April 1 not much should be expected from the vines unless steps are taken to keep the house as cool as possible. This may be accomplished by shading, and by a free use of water upon the walks of the house.

From a financial standpoint, the growing of peas can scarcely be advised, but amateurs may derive much satisfaction from their culture as the plants are easily grown, they require little care, and the quality of the peas is especially appreciated when no fresh ones are on the market.

BEES IN GREENHOUSES.

Much has been written regarding the value of bees in greenhouses. It is said that all hand pollinations may be dispensed with if desired, as the bees will work among the blossoms and thus cause the fruit to set.

During November, 1893, a hive of bees was received, and on the 23d day of the month they were set free in the brightest of

*See Bull. 30, p. 92.

all the station houses (shown on the title page). The hive was placed at the south end of the house, and the bees were kept constantly supplied with proper food. At this time the house was filled with tomato plants in full bloom, and it was hoped the bees would work among them so that the tedious but very necessary hand pollination of the flowers need no longer be practiced. The bees evidently did not catch the idea, however, for if there was one place in the house which they did not visit it was the tomato blossom. They spent most of their time in bumping their heads against the glass sides and roof of the house, and at every opportunity, when the ventilators were raised a little, they took pains to pass through them, even though the mercury stood far below the freezing point out of doors. The bees which did not succeed in finding the ventilators continued to fly against the glass, leaving it only for the purpose of withdrawing far enough to get a start for a fresh attack. In this way the busy bee finally wore herself out, and, in the course of three weeks, those less ambitious individuals which did not fly heavenward in the friendless atmosphere of December, were scattered as corpses along the sides of the house close to the glass; and thus ended the attempt to make these little creatures useful in midwinter. It may be said that bees do not like tomato flowers, but our specimens took no pains to find out whether they liked them or not. It is probable that every bee in the swarm went to his honeyless bourne without ever having discovered whether the plants were tomatoes or buckwheat, or, in fact, if there were any plants at all in the house.

METHODS OF CONTROLLING GREENHOUSE PESTS BY FUMIGATION.

The insects and the fungi which seriously injure greenhouse plants are comparatively few in number, but if allowed to develop unchecked they are capable of entirely ruining every susceptible plant in the houses. There are some plants which are almost entirely free from such attacks, but they form isolated exceptions to a very general rule. All who have had any experience in growing plants under glass know that diseases are sure to appear

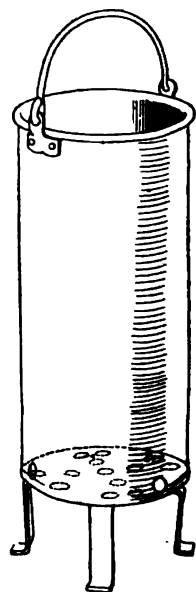
and that insects will originate apparently from nothing. Indeed, so certain are these pests to appear that every thorough gardener is at all times prepared for them, or even takes steps towards their destruction before they have been seen. Fortunately, he has at his command abundant means of protecting his plants, and houses in which insects or fungi are found in large numbers are silent but convincing witnesses of bad management and neglect. When a greenhouse has once become thoroughly infested, it is almost impossible to rid the plants of their parasites, and it requires constant and prolonged attention to bring about this result; and even when this has been done, the plants will in many cases have become so weakened that they will scarcely repay the time and labor employed in saving them. The care of plants should begin before they are attacked, and this care should be given uninterruptedly. By treating apparently uninfested plants many invisible enemies may be destroyed, and such treatments are by far the most valuable ones.

Tobacco.—Several of the most common and often very serious organisms may be overcome by vapors with which a house may be filled, and the best known and the most valuable remedy of this nature is undoubtedly tobacco. The poisonous alkaloids found in the tobacco plant are fatal to many insects. The waste parts of the plants, particularly the "stems," are utilized by florists and others for purposes of fumigation.

These stems, which are almost invariably the dried mid-veins of the leaves, may be obtained for almost nothing at any cigar factory. When wanted for fumigating purposes they should not be too dry, else they will blaze, instead of slowly smouldering and forming a dense smoke. In case the stems are too dry, they may be moistened by sprinkling water upon them; a better way, however, is to store the stems in a moderately damp place, and then they are always in good condition for burning. If they blaze while the house is being fumigated, much of their value is lost, and it is also said that plants are positively injured in such cases, although our experience has not supported this view.

Tobacco stems may be burned in a variety of ways. Some gardeners merely pile the required quantity upon a brick or stone floor in the house and set fire to it by means of paper or shavings.

An old coal scuttle answers the purpose very well. Figure 75 represents a tobacco-stem burner which we have designed, and which is perhaps as simple, serviceable, and easily managed as any in use. The body of the burner is made of heavy, galvanized sheet-iron. It closely resembles a stove pipe in form, but is about seven inches in diameter and two feet in length. The bottom is made of the same material; it is perforated by about a dozen holes, each three-eighths of an inch in diameter. Four legs support the burner and keep the bottom three inches from the floor. A handle at the top completes the device. When filled, the stems being packed sufficiently close to insure their burning, it contains an amount that will answer for a house of 4,000 to 6,000 cubic feet. Much, of course, depends upon the tightness of the house, and considerable variation will also be found in the strength of the stems. Occasionally some will be had which are much weaker than those last used, and hence larger quantities must be employed. It has been our practice to test each new lot of stems to determine their strength before they were freely used in all the houses. The quantity must also be varied in accordance with the plants growing in the house. Some plants are much more easily injured by the smoke than others, and the amount used must be insufficient to hurt the most tender plants. Less injury is apt to result if the houses and plants are dry; wet foliage is quite easily scorched by the smoke. Our method of starting a "smudge" is to place a single sheet of newspaper, previously lighted, in the bottom of the burner, and upon this the stems are immediately placed. If properly dampened, they will take fire readily and smoulder without blazing.



75.—*Home-made tobacco fumigator.*

The frequency with which a house should be smoked cannot be definitely stated. Some conservatories will require the operation scarcely more than two or three times during the winter, while others may need that many treatments each week. In the latter

case, it is well to have the smudges upon consecutive days, as in this manner insects receive a second treatment before they have recovered from the first. The evening is perhaps the best time for fumigating, as most of the disagreeable odor is thus escaped. But it may be advisable, in badly infested houses, to follow the evening treatment by another the next morning. In such cases, care should be exercised that the houses do not become overheated by the morning sun.

Tobacco smoke may be used successfully in the destruction of the various aphides which are found upon greenhouse plants, and of a small white fly, a species of aleyrodes. Other insects cannot be practically treated by its use.

Bisulphide of carbon has recently assumed a prominent position as an effective insecticide. It is a clear transparent liquid which evaporates rapidly even at a low temperature. These fumes are fatal to insect as well as animal life, and may be used to a limited extent in the greenhouse. The vapor is of greatest value in destroying a small mite (*Tetranychus bimaculatus*), that closely resembles the red spider. This mite is not as easily overcome by water as is the red spider, and in certain cases it may be advisable to resort to the bisulphide of carbon treatment. This treatment is adapted to plants which are growing in pots, or to low growing plants in beds. Whole houses could scarcely be treated in this manner, as the vapor is heavy and an uneven distribution would probably result. But for small, confined spaces, as bell jars, tubs, or barrels, the remedy can be used with success. I have had no difficulty in destroying mites and red spider by the use of 60 minims or drops of the liquid to a space containing about 7 cubic feet. The liquid was poured on cotton batting which was spread over a small rose from a watering can, the stem of the funnel being set in the soil. The plants remained covered with enamel cloth, nearly two hours, which sufficed to kill all the insects, and did not injure the violets, these being the plants treated.

Hydrocyanic gas.—The success which has followed the use of hydrocyanic gas in the treatment of scale insects infesting the orange groves of California has suggested the idea of its possible value in destroying greenhouse pests. The common method of

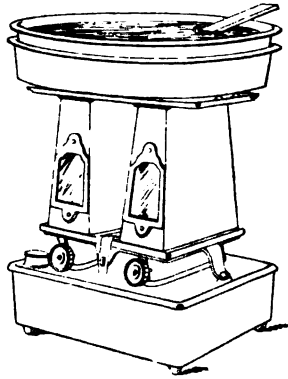
making the gas is as follows : One fluid ounce of sulphuric acid is added to 3 ounces of water. To this diluted acid there is then added 1 ounce of 60 per cent. cyanide of potassium. Effervescence immediately takes place, and the gas is freely given off. The quantities here given are sufficient for a space containing 150 cubic feet, the plants being exposed to the gas for 1 hour. When trees are dormant, such treatment is not followed by any evil effects.

During the past spring several growing plants were exposed to the action of the gas when used according to the above directions. Tomatoes, egg-plants, oranges, and roses were used. The day following the treatment showed that all the plants were injured, but to what extent could not be well determined. After two weeks had passed, however, the effect of the treatment was plainly seen. The tomato plant died ; the egg-plant and the rose lost all their foliage, but fresh leaves were appearing on the stems ; the orange suffered the least, since only the young leaves were affected. The mites had all been killed, so that in this respect at least the experiment was successful.

Other trials were made with the gas, using the same kinds of plants, but it was found to be impossible to destroy the mites without injuring at least some of the plants. The use of hydrocyanic gas for the destruction of greenhouse pests can therefore scarcely be recommended. It should also be remembered that this gas is very poisonous.

Sulphur is an element which is of the greatest service in greenhouse work. It is an invaluable agent for the destruction of mildews, and is also of great assistance in overcoming red spider. As commonly use, it is mixed with an equal bulk of air-slaked lime or some similar material, and then water, oil, milk or some other liquid is added until a thick, creamy paste is obtained. This is then painted upon the heating surfaces in the house, and the sulphur fumes are given off. The same result can be obtained much more rapidly and energetically by heating the flowers of sulphur until it melts ; the fumes are then given off in great abundance. Our practice has been to put the sulphur in a shallow pan and then set it over an oil-stove, having the flame turned just high enough to keep the sulphur in a melted condition. Almost con-

tinuous watching was necessary to prevent the material from taking fire, for if this should occur it would prove almost instantly fatal to all the plants which might be reached by the gas. The difficulty was in a great measure overcome by L. C. Corbett, at that time an assistant in this department, who suggested the use of a sand-bath as a means of modifying the intensity of the heat. Our present outfit is shown in Fig. 76. It consists of two pans placed on an ordinary hand oil-stove. The lower pan is half filled with clean, coarse sand, and the upper one contains the sulphur. By its proper use our houses have been kept remarkably free from mildew, even under very adverse circumstances. But there is constant danger that the sulphur will become heated to the burning point, and then the entire stock of plants in the house is lost. This use of sulphur is often very convenient, but the work should be placed in the hands of a most trustworthy person. If a house should be thoroughly treated in this manner every week or two, scarcely any mildew could develop.



76.—Apparatus for evaporating sulphur.

TREATMENT OF CARNATION RUST.

There is probably no disease of carnations which is a greater menace to their successful culture than the rust. This disease is caused by a fungus (*Uromyces caryophyllinus*). It is of European origin, and was first reported in this country in 1891. On account of the rapidity with which the disease has spread, and the serious losses that follow its attacks if allowed to develop unchecked, it has been ranked among those which are treated with difficulty. It appears probable that some exaggerated statements have been made regarding its control, yet carnation growers cannot be too careful in adopting all measures that may prove effective in destroying the parasite.

The disease has been rapidly introduced into all parts of the country by means of diseased stock sent out by propagators. The first item in growing a healthy lot of carnations is to have the plants free from disease when they are set in the bench. All rooted cuttings received from other growers should be closely examined, and the affected ones discarded. The same protection should be taken at the time of setting the plants in the benches. It is only in this manner that a clean start can be made, and even in spite of such care, the trouble appears only too frequently.

During 1894, some new varieties of carnations were sent us for testing, and with the plants came the rust. For obvious reasons these plants could not be discarded, and the attempt was made to grow them in a bench which was also set with carnations of standard varieties, these being entirely free from the disease.

The bench was planted during September, but no fungicide was applied until November 17. At this time the rust had spread among the healthy plants that were growing next to the affected ones, about a dozen being diseased. Some were so seriously attacked, however, that steps were taken to check the spread of the disease.

Two mixtures were applied. The first consisted of the Bordeaux mixture* to which was added soap. This addition was made in order to render the mixture more adhesive. Varying quantities of soap were tried, but the stated amount proved as satisfactory as any. The foliage of carnations is particularly difficult to wet, and much trouble was experienced in obtaining a uniform application. The soap appeared to possess a certain value in preventing the mixture from collecting in drops and rolling from the leaves, yet this action was not as marked as was desired. It was found, however, that if an extremely fine spray was made the liquid could be fairly well distributed.

The second mixture contained bichloride of copper and air-slaked lime.† Soap was added to this mixture for the reasons

* Copper sulphate 6 pounds, quicklime 4 pounds, soap 1½ pounds, water 45 gallons.

† Copper bichloride 2 ounces, air-slaked lime 2 ounces, soap 10 ounces, water 12 gallons.

given above, and the preparation behaved in a manner very similar to that of the Bordeaux mixture.

As already stated, the first application was made November 17; this was followed by a second on the 24th. The plants were covered as well as possible, the entire bench receiving treatment. No check plants were left, as the extermination of the disease, so far as possible, was attempted. The effects of the treatment however left nothing to be desired. Not only was the spread of the disease stopped, but affected plants put out new growths which remained healthy. At the time of making the applications, all parts affected with the rust were removed when possible, and this also tended to check the trouble. Still, when one considers the enormous number of spores produced by the fungus, and that these may infest healthy tissues at any time when the proper conditions of heat and moisture are present, this sudden check to the spread of the disease is very encouraging, and makes the successful control of carnation rust by the use of fungicides very probable. If in addition to such treatment, care is exercised in selecting only healthy plants for propagating purposes, and all affected parts are removed as soon as discovered, little danger need be feared from this disease.

L. H. BAILEY.

E. G. LODEMAN.

0 50. 0 17
N 7
C 8 el
Bulletin 97.

July 1895

Cornell University Agricultural Experiment Station.
Botanical and Entomological Divisions.

Studies in Artificial Cultures

OF

Entomogenous Fungi.

By R. H. PETTIT.

**PUBLISHED BY THE UNIVERSITY,
ITHACA, N. Y.
1895.**

ORGANIZATION.

BOARD OF CONTROL:

THE TRUSTEES OF THE UNIVERSITY.

STATION COUNCIL.

President, JACOB GOULD SCHURMAN.

Hon. A. D. WHITE,	-	-	-	-	Trustee of the University.
Professor I. P. ROBERTS,	-	-	-	-	President State Agricultural Society.
Professor I. P. ROBERTS,	-	-	-	-	Agriculture.
Professor G. C. CALDWELL,	-	-	-	-	Chemistry.
Professor JAMES LAW,	-	-	-	-	Veterinary Science.
Professor A. N. PRENTISS,	-	-	-	-	Botany.
Professor J. H. COMSTOCK,	-	-	-	-	Entomology.
Professor L. H. BAILEY,	-	-	-	-	Horticulture.
Professor H. H. WING,	-	-	-	-	Dairy Husbandry.
Professor G. F. ATKINSON,	-	-	-	-	Cryptogamic Botany.

OFFICERS OF THE STATION.

I. P. ROBERTS,	-	-	-	-	-	Director.
E. L. WILLIAMS,	-	-	-	-	-	Treasurer.
H. W. SMITH,	-	-	-	-	-	Clerk.

ASSISTANTS.

M. V. SLINGERLAND,	-	-	-	-	-	Entomology.
GEO. C. WATSON,	-	-	-	-	-	Agriculture.
G. W. CAVANAUGH,	-	-	-	-	-	Chemistry.
E. G. LODGMAN,	-	-	-	-	-	Horticulture.
MICHAEL BARKER,	-	-	-	-	-	Horticulture.

Office of the Director, 20 Morrill Hall.

Those desiring this Bulletin sent to friends will please send us the names of the parties.

BULLETINS OF 1895.

84. The Recent Apple Failures in western New York.
85. Whey Butter.
86. Spraying of Orchards.
87. The Dwarf Lima Beans.
88. Early Lamb Raising.
89. Feeding Pigs.
90. The China Asters.
91. Recent Chrysanthemums.
92. Feeding Fat to Cows.
93. The Cigar-Case-Bearer.
94. Damping Off.
95. Winter Muskmelons.
96. Forcing-House Miscellanies.
97. Entomogenous Fungi.

On account of the technical nature of this Bulletin, only a small edition is printed for the use of Experiment Stations and Exchanges.

STUDIES IN ARTIFICIAL CULTURES OF ENTOMOGENOUS FUNGI.

Most insects are subject to contagious diseases which determine to some degree the extent of the ravages of injurious species and which, at times, destroy beneficial ones. The possibility of controlling these diseases, and of introducing epidemics where they are desirable, has led several investigators to carry on researches in this direction; and the results of some of these investigations have led their authors to believe them of considerable economic importance.

The subject has become one of general interest, and it is desirable to have as complete a knowledge as possible of the affinities and life histories of such entomogenous fungi as are capable of artificial cultivation. The object of the present paper is to determine by means of artificial cultures, the life histories and the relationship of the forms studied as well as to carry on preliminary studies respecting the practicability of introducing diseases among insects. Most of the forms studied are members of the genus *Isaria*, and its perfect form *Cordyceps*; the others are species of the genus *Sporotrichum*.

The material from which the present study was made has been obtained from specimens collected in the vicinity of Ithaca, N. Y., or kindly sent by others. The studies in artificial media were made in the laboratory of cryptogamic botany in Cornell University under the supervision of Professor G. F. Atkinson. The experiments in the infection of insects were carried on in the insectary of the Cornell Agricultural Experiment Station under the supervision of Professor J. H. Comstock.

When a study with artificial cultures is to be made, the first step is to separate the disease-producing organism from the accompanying bacteria and fungi, and to grow it in pure cultures. To do this, plate cultures are made with nutrient agar or some like preparation. In the present work, nutrient agar, the ordinary agar-agar-peptone-broth, has been used, except in one or

two cases where the organism refused to grow and produce spores on this substance. In these cases potato-agar, made from potato and agar only, was employed.

To separate a fungus a small portion containing spores is removed usually to a slide and teased apart in a little water. Meanwhile three tubes of agar have been placed in the water-bath and heated until the agar is melted. They are then cooled in water to 43° Centigrade, and the spores and pieces of fungus on the slide are washed into the first tube and well shaken. A drop or two is now poured into tube number two and shaken, and the process is repeated with tubes number two and three. It is now probable that by this repeated dilution only a few organisms have been transferred to tube number three. In separating spores of fungi this method of pouring a drop from one tube to the next, is preferable to dipping in a sterilized needle as is usually done in transferring bacteria, for the spores of fungi are so much larger than bacteria that the number of fungus spores, which would cling to the needle, would be small in proportion to the number of bacteria which would also be transferred with them. By pouring out a drop, the proportion of fungus spores to the bacteria present remains unchanged. The contents of each tube is now poured into a sterilized Petrie-dish. The melted agar spreads evenly over the bottom of the dish and soon hardens into a firm, jelly-like layer, thus fixing in position any organisms present. Bacteria and spores of fungi grow freely in this layer, and the plate may be placed at any time under the microscope and the progress examined. Moreover the organism, being fixed, is obliged to confine its growth to a relatively small area. Isolated growths or colonies starting from a single organism or spore may usually be found in the second plate and often in the first. It is well to make studies from such isolated growths, for if two run together it is possible that they will contain more than one species. A small portion may now be removed on the point of a sterilized platinum needle and transferred to a stick of sterilized potato or other suitable medium. A pure culture is thus obtained. It is also sometimes possible to obtain a pure culture direct from the insect by touching a sterilized needle to the spore-bearing stroma and then to a tube of potato.

CORDYCEPS CLAVULATA (Schw.) ELLIS*.

One often finds, in moist or shady places, the remains of scale-insects belonging to the genus *Lecanium* on which are growing the delicate fruiting bodies of a small fungus. These fruiting bodies are between two and three millimeters long, and terminate in a more or less conical head about one millimeter in diameter, Fig. 97. The color is brown or black. These heads are covered with small rounded papillate projections which are the openings of flask-like conceptacles containing the reproductive bodies. The scale on which the fruiting bodies are borne is often shrunk-en so completely by the fungus and partially or wholly replaced by it that it appears as a lenticular base belonging to the fungus. On crushing one of these heads, one finds many sacs called asci. Each sac contains eight slender cylindrical spores which are divided by septa into about twelve or fifteen segments. This fungus is found on scales infesting various trees. Schweinitz** found it on black ash, on *Quercus palustris*, and on *Q. coccinea*. Dr. Peck found it† on *Fraxinus sambucifolia*. I have found it on *Acer pennsylvanicum*, on wild cherry, on butternut, on juniper affected by *Lecanium fletcheri* and on various species of *Quercus*. The species was first described by Schweinitz.*† Berkeley and Broome,‡ afterward described an English form, *Cordyceps pistillariaeformis*, which may be the same. Dr. Peck† refers the specimens found by himself to Schweinitz's species.

On May 13th, 1895, I found a maple, *Acer pennsylvanicum*, badly infested with a scale-insect, *Lecanium* sp. Many of the scales appeared abnormally yellow, some approaching bright orange in

**Technical description of Cordyceps stage*.—Sporophores slender, from 2 to 3 mm. long, bearing a conical head slightly less than 1 mm. in diameter and somewhat longer than broad. Perithecia sub-immersed and rounded, containing fusiform, eight-spored asci about 120 microns long (Fig. 11). Spores ten to twelve segmented and from 3 to 3½ microns in diameter (Fig. 12). The color is fuliginous tinged with yellowish green.

**Synopsis of N. A. Fungi, No. 1155.

†28th, Rept. N. Y. State Mus., p. 70.

‡No. 969, Brit. Fungi.

color. On teasing one apart in water and examining it with a microscope, it was found to be teeming with small, oval or ellipsoidal, hyphal bodies, very closely resembling yeast. Some were almost fusiform. These bodies often contained one septum and the interior was partially or wholly filled with large granules of an orange color tinged with green. In some cases constrictions were to be seen in the larger bodies, and always at the point where the septum was located (Fig. 1).

A dilution culture was made on May 14th, and in two days one or more slender germ-tubes had been put out at one or both ends of the hyphal body. After five days the growth stopped. Pieces of agar, containing live and growing bodies, were removed and placed in acidified agar, but no further growth took place. On May 16th, a red cedar, *Juniperus virginiana*, was found infested with another scale, *Lecanium fletcheri*, and as some of these appeared very much like the ones on maple, they were also examined. Bodies closely resembling those in the first scale were found. They differed only in being larger and once or twice septate (Fig. 4)*. A dilution culture was made and germination took place as in the first instance, with, however, a more vigorous growth. Fig. 5 shows the bodies after one day; Fig. 7 a portion of the mycelium after two days. Septa and a few small vacuoles appear about this time. Branching occurs quite profusely and irregularly. Fig. 6 shows a portion of the mycelium after five days. Many large and regularly placed vacuoles are present and the threads are constricted between the vacuoles. Small pieces of agar containing this growth were transferred to tubes of acidified agar, and some were also transferred to tubes containing potato steeped in a strong infusion of *Lecaniums*. Out of a large number of tubes, two showed a growth of very fine, white, cottony filaments which in time became quite dense and somewhat matted. On examination this growth is found to consist of long, fine filaments bearing, at irregular intervals, flask-shaped sterigmata placed at right angles to the parent thread, and which taper to a fine point and bear usually one oval or ovate

*Since that time, specimens identical with these have been found on maple and specimens similar to the ones first found were also seen in *L. fletcheri*. It seems almost certain that the two forms are specifically one, as intergrading forms are present in both cases.

conidium from 3 to 4 microns in size. The thread is filled with hyaline protoplasm containing small granules (Fig. 9). Sometimes there is a short side branch from the tip of the sterigma which bears a second spore (Fig. 9). From these cultures conidia were transferred to tubes containing sterilized sticks of elm covered with coccids. A vigorous growth was in this way obtained. About this time, a coccid was torn apart and examined. It was seen to be full of hyphal bodies like those first found but somewhat swollen, and producing nearly straight germ tubes (Fig. 3). A little later coccids were found having a white fringe around them, and bearing on the back small white projections like the beginnings of sporophores, composed of many threads growing together and producing a solid mass. This is the beginning of the Isaria-stage. On examining the fringe a condition of affairs similar to that found in the cultures was observed, the flask-shaped sterigmata and conidia exactly resembling those seen in the cultures. On keeping these coccids in a moist-chamber for a few days, a dense, white, cottony growth similar to that produced in the cultures appeared, covering the scale. Somewhat later a reddish powder was seen borne directly on the coccid. This proved to be made up of bodies similar to the hyphal bodies (Figs. 1 and 4). I was unable to observe the manner in which they were borne, and have been unable to produce this stage since. The short sporophores mentioned as the beginning of the Isaria-stage, continued to grow, and on examination were seen to be made up, at first, of loose fibres which unite to form a slender white sporophore bearing sterigmata and conidia resembling those in the fringe and in the cultures. Fig. 98 shows a number of coccids at this stage.*

* *Isaria-stage*.—The sporophores are simple, slender, terete or cylindrical, and white; they are borne in groups of from two to ten on the dorsal surface of scale-insects belonging to the genus *Lecanium*. The sporophores are 1 to 2 mm. long, formed by the interlacing threads of mycelium and bearing sub-ovate conidia $2\frac{1}{2}$ to 4 microns in size, on simple or once branched flask-shaped sterigmata, which are placed at right angles to the thread. The scale-insect on which these sporophores are borne is often surrounded by a simple fringe of mycelium (Fig. 98), which also bears conidia. The apices of these Isaria-sporophores become enlarged into the ascophores of the perfect stage.

The cultures on sterilized scales afterward produced sporophores of the true *Isaria* type, about 3 mm. in length and $\frac{1}{2}$ mm. in diameter. They resembled in every way the sporophores found on scales growing under natural conditions. After nearly seven months, transfers were made from these cultures to sticks of potato and pure cultures obtained. When growing under natural conditions, the apex of the *Isaria*-sporophores becomes enlarged and assumes the form of a conical head bearing closely packed rounded perithecia which contain many asci about 120 microns in length and 13 in diameter. They are fusiform and taper to a slender base. At the apex the spores do not entirely fill out the ascus, leaving the appearance of a small hyaline cap, formed by the membrane of the ascus. The asci contain eight spores, which are long and slender and fuliginous in color. In the younger stages they are filled with small vacuoles. Later the vacuoles disappear and the spores become divided by from ten to twelve septa. Fig. 11 shows two asci before maturity and one at maturity.

On July 7, a dilution culture was made of the ascospores, using agar in which was a strong infusion of coccids. After two days, germination had commenced. The spores, usually remaining in the ascus, put out, at various intervals, slender, sinuous germ-tubes, containing fine granules. In some cases the tubes were closely packed coming from many of the segments of the spores (Fig. 13). After three days the threads become full of vacuoles, and constrictions appear between them. At this stage the plate became so badly contaminated with bacteria that it was impossible to further observe the development.

On potato the growth proceeds slowly, forming a dense dirty-white mat somewhat uneven in surface, and turning the adjacent potato a deep bluish black color.

The economic value of this fungus is probably small. The fungus abounds on scales which grow in damp and cool gorges and refuses to flourish in dry situations. The cedar from which many of the specimens studied were obtained was situated on a dry hillside, and although the scales were very many of them full of hyphal bodies, no sporophores were afterward seen. It is possible that these hyphal bodies play an important part in the spread of the disease, and being very inconspicuous they may

grow in this stage until conditions favorable to the production of the *Isaria*—or *Cordyceps*—stage are brought about. It would be very interesting to try experiments with scale-insects in a region having a moist climate or season suitable to the propagation of this disease.

CORDYCEPS MILITARIS (Linn.) Link.

On Oct. 14, 1894, Miss Green, a student in the University, found a specimen of a *Cordyceps* partially buried in decaying leaves, in wood-land, at Enfield gorge. Unfortunately no search was made for the insect, but the sporophores were simply pulled up and brought to the laboratory. Two sporophores were found about 3 cm. in length (Fig. 92). They were clavate in form and orange in color. The deep reddish perithecia are immersed in the light buff stroma. Near the base the perithecia are more prominent. The perithecia are conical, tipped with a pale yellow ostiolum, which is prominently pointed until the spores escape, when it collapses. The distal half of the sporophore is fertile. The spores are thrown out in a loose flocculent mass and remain clinging to the surface. They are about $1\frac{1}{2}$ microns in diameter, and have segments 3 microns in length (Fig. 40). Eight spores are borne in a long tapering ascus (Fig. 39), the base of which is usually broken in preparing mounts, leaving the spores to protrude in a brush. The ascus is about $3\frac{1}{2}$ or 4 microns in diameter.

This specimen was carefully compared with four specimens from Europe kindly loaned by Mr. J. B. Ellis. They differ slightly in having perithecia somewhat less deeply immersed, but the measurements are the same. The variety which is described on page 347 differs in having the perithecia not immersed, and in having the spores much larger. It also develops into the typical form of *Isaria farinosa* while the form under discussion produces a conidial stage quite different.

A dilution culture was made in the ordinary way using potato agar. Many segments of spores were sown. They were taken from the flocculent mass of spores protruding from the asci. No other spores were visible except the typical ascospores, but when germination took place, the growth appeared from rounded spores much larger than those sown. This was doubtfully explained by supposing that the large rounded spores were those of the cor-

responding *Isaria*-stage, which remained clinging to the sporophore after the manner of *Cordyceps clavulata*. It also brought up the case of the variety of *Cordyceps militaris* whose similar behavior had been partially explained in the same way. This explanation, however, did not make clear how the majority of the germinating spores were rounded, while those sown were, so far as seen, small and cylindrical.

Accordingly another dilution culture was started, and this time an examination was made soon after sowing. After one hour, numbers of the true *Cordyceps*-spores were visible but no rounded ones. After twenty hours there were visible many connected chains of rounded bodies, closely resembling the conidia of *Isaria farinosa*. In several cases large portions of the ascus were visible, with nearly all the segments of the spores swollen to the rounded form, and just enough of them retaining their original form to prove that they were really from the original ascus of the *Cordyceps*.

Germination from these swollen spore-segments takes place by the production of germ-tubes at one or two points. These soon become branched. The protoplasm is at first hyaline and homogeneous. After three days large vacuoles appear irregularly placed. The threads are strongly segmented and the branches are strongly constricted at the base. In some cases a healthy thread becomes suddenly constricted and produces an aborted apex of less than half the diameter of the ordinary thread (Fig. 45). The aborted portion is usually curled. In some cases the entire growth presents a much swollen appearance, being about twice the diameter of the ordinary threads. The segments of these swollen colonies always contain large vacuoles (Fig. 46). In about four days the growth appears above the surface of the agar. A strong, white, cottony growth appears forming a colony circular in form. At the end of about six days the conidia appear. Short sterigmata are borne near the ends of the long, cottony threads. They are irregularly arranged either in an opposite or an alternate manner. They are flask-shaped and slender and sometimes forked. The conidia are nearly spherical and are borne in short chains of three or four at the ends of the sterigmata, or at the end of a long thread. The chains are seldom seen for they almost invariably collapse leaving the conidia in balls at the ends of the sterig-

mata. This is probably due to a thin film of moisture clinging to the surface.

The growth on potato becomes visible after about six days. The light yellow or white mycelium spreads loosely over the surface of the potato. After about a month the surface becomes densely felted, and in another month it becomes buff in color. The mycelium on the surface of the potato and the potato itself are colored pale orange or brilliant chrome yellow wherever they touch the glass. No *Isaria*-sporophores have been observed. A culture was made in a half-litre flask of potato, and quite a marked difference in the habit of growth was seen between this and the smaller tubes. The flask culture showed the beginning of a sporophore, deep reddish-orange in color, at the end of about three months. This is probably the beginning of an ascophore, since it appeared after the conidial growth had ceased, and at the same time that rudimentary perithecia were produced. The color also agrees with the color of the original specimen, which is in the perfect stage. At the end of two months, many small rounded bodies (Figs. 52 and 53), probably undeveloped perithecia, were developed in the potato just under the layer of mycelium. These bodies were usually spherical and measured from 100 to 240 microns. Sometimes two or three unite into a compound mass. No asci are visible on crushing them.

CORDYCEPS MILITARIS var.

The specimen from which this study was made was found by Professor Atkinson in the fall of 1893, on the larva of some unknown insect which was buried in rotten wood. The two slender orange colored sporophores protruded, bearing heads about $1\frac{1}{2}$ mm. in diameter and 2 to 3 mm. in length. The entire sporophore is about 1 cm. in length. The heads of this form are apt to be more nearly globose than the typical form. The perithecia are crowded with their bases only, immersed. The form is conical, ending in a dark ostium. The asci are long, slender, tapering to a slender base. They are from 200 to 280 microns in length. The apex is slightly swollen and empty, giving the appearance of a hyaline cap. The long, slender spores are divided into segments about 3 microns in diameter, and 6 to 9 microns in length (Figs. 21 and 22).

On May 31, a dilution culture was made and from it a pure culture of a form apparently identical with *Isaria farinosa* was obtained. But as it was impossible to trace the germination from the cylindrical segments of the ascospores, a second dilution culture was made. The material was this time taken from an unripe portion of the head and no growth resulted. A third time the sowing was repeated in hopes of tracing the germination from the ascospores. At the end of two days, however, the spores from which the growth proceeded did not resemble ascospores but were oval and larger. The small number of ascospores was noticeable, for when sown, no spores except ascospores were visible, and after two days, fully three-fourths of the spores present were of the oval type. The cylindrical spores remaining refused to germinate. One more dilution culture was made with no better results, and the material having been nearly exhausted, the attempt was abandoned. From a later study of *Cordyceps militaris*, I have come to believe that the larger oval type of spore is merely the inflated state of the true ascospore. Although no oval spores were, in this case, seen to remain in chains, it would seem that the disappearance of the ascospores, and the simultaneous appearance of the oval type, which subsequently developed into the form apparently identical with *Isaria farinosa*, would prove the identity of the two. Potato cultures developed exactly as cultures obtained from the typical *Isaria farinosa*.

Tulasne was the first to remark the connection between *Isaria farinosa* and what he identified as *Cordyceps militaris*.* He says the segments of the spores of *Cordyceps militaris* put out threads in germinating which branch after the manner of *Verticillium*, and bear conidia resembling those of *Isaria farinosa*. He also found what he took to be the conidia of *Isaria farinosa* among the "roots" of the ascophores.

De Bary says:† "If the ascospores be sown in water or in nutrient solutions without a living host, they germinate and the germ-tubes develop hyphæ which branch with more or less copiousness according to the amount of nourishment supplied. In water only small plants are produced with few or no branches.

* *Selecta Fungorum Carpologia*.

† *Comparative Morphology and Biology of Fungi, Mycetozoa and Bacteria*.

Some of the branches spread in the nutrient solution, and have the power like the hyphæ on the inner surface of the caterpillar's skin, of adjoining cylindrical gonidia. It is true that this has not been observed in the species in question."

Since this form differs markedly from the typical *Cordyceps militaris* in the spore characters, it would be interesting to know if the specimens studied by De Bary and Tulasne, and thought by them to be connected with *Isaria farinosa*, possessed spore-characters identical with this form, or if the difference in the imperfect stages is due to variation. This question can only be settled by making cultures from the ascospores of various specimens.

Isaria farinosa (Dicks.) Fr.

The typical form.—The following study was made from material collected by Professor Atkinson in the fall of 1893, on an Arctiid cocoon buried in leaves in the woods. The cocoon was covered with sporophores about 3 or 4 cm. long. These sporophores are orange colored at the base, the apical two-thirds having a white farinaceous covering composed of colorless conidia, borne in a manner resembling that of *Penicillium* on loose threads which spring from the interwoven threads composing the sporophore. The conidia are borne in long chains on flask-shaped sterigmata which are grouped at the ends of short side branches.

A dilution culture was made from this. The growth in agar plates becomes apparent at the end of about twenty-four hours after the sowing of the conidia. They become swollen and put out one or two germ-tubes, usually at one or both ends of the slightly oval conidia. The protoplasm is homogeneous and hyaline. At the end of two days, the growth becomes apparent to the unaided eye. Branching occurs freely, the branches tapering and slightly constricted at the base. A few vacuoles appear and at the end of three days a few septa are to be seen, usually just beyond the point where a branch is attached. After about four days the threads are thrust up out of the agar, and in two more the colonies form beautiful, circular, cottony growths very finely radiate. The conidia now appear, borne on flask-shaped sterigmata which are placed either singly or in groups of from two to twelve on the main thread or on the end of a short side

branch. The oval or nearly spherical conidia are borne in chains at the apices of the sterigmata.

A small depauperate form, probably of this species, was found feeding on a group of insect's eggs (Fig. 93). This specimen produced two sporophores, recumbent for a short distance, and then rising in a cylindrical mass of fibres for 6 or 7 mm. and bearing at the apex a spherical head about 1 mm. in diameter. One of the sporophores was forked just below the apex and bore two heads packed with loose chains of creamy white conidia. Plate-cultures from this specimen developed like those from the typical form, except that the threads became somewhat more swollen. A specimen found on decaying leaves showed a development coinciding exactly with the typical form.

On potato, the growth spreads rapidly over the entire surface, forming a dense, white covering of considerable thickness. This felt spreads evenly over the surface of the liquid and reaches to the glass walls of the tube. *Isaria*-sporophores are produced which grow directly away from the potato for a distance, when some of them reach the sides of the tube and grow directly upward for 2½ cm. or more, clinging to the glass, and flattening out considerably. Many short, round, rudimentary sporophores are produced all over the sides of the stick of potato. The bases of the sporophores are usually buff and the mycelium shows, where it touches the glass, a buff color at first which afterward becomes orange. In old cultures, long attenuated, the general color becomes buff or even pale orange.

A half-litre Ehrhlmeyer-flask containing about 2 cm. in depth of potato on the bottom, was inoculated with conidia of *Isaria farinosa*. A very luxuriant, loose and white growth soon appeared, many sporophores being produced from 2½ to 4 cm. in length, covered with a farinaceous coat of conidia on the distal half. The flask, which had been previously kept in the dark, was placed in the light. In a short time a bright orange-color replaced the white to a great extent. On returning the flask to the dark, the growth became pale and a white, flocculent growth soon overspread the entire culture. On again bringing it to the light the orange-color reappeared.

EXPERIMENTS.

A number of white grubs, the larvae of *Lachnosterna*, were dusted with conidia both from the original specimen and from potato cultures, and after four months, no trace of the fungus was visible. Although most of the specimens died, they showed no trace of the fungus.

Fifteen specimens of *Pieris rapae* (larvae) were dusted with conidia from a potato culture. After about twenty days the adult insects emerged.

Seven specimens of our common brown-and-black caterpillar, *Pyrrharctia isabella*, were infected with *Isaria farinosa* by sticking the conidia on the ventral and lateral surfaces with the white of an egg, by means of a brush. After twenty days, all but two showed that they were attacked by the fungus. Of the five attacked four were dead, curled up and covered more or less densely with a thick cottony mass of mycelium most prominent on the ventral side. One was yet alive although the ventral side bore patches of the mycelial growth. One of the dead larvae was placed in a pot of sterilized sphagnum moss and placed in a moist chamber. After a little more than a month it had become completely covered with long *Isaria*-sporophores like those found on the original specimen. The remaining caterpillars and the two which subsequently contracted the disease, did not produce sporophores. They were left in the original cage which was constructed as follows: an ordinary flower-pot was placed inside of a larger one and the space of about 2 cm. between them was packed with moss. The inner jar was closed by an inverted jar intermediate in size between the two. The moss packing was moistened daily, thus maintaining a humid atmosphere suitable for the best growth of the fungus, and approximating the conditions of the natural fall and spring home of the caterpillar.

ISARIA TENUIPES Peck.

The material from which the present study was made was obtained during the summer of 1894. Professor Atkinson collected two specimens on the pupae of unknown Arctiids, buried in leaves. From seven to ten slender, clavate sporophores arise from 1 to

1½ cm. above the pupae. The distal half is flattened and densely covered with a farinaceous white powder composed of colorless conidia. The base is greenish-yellow and sterile. The conidia are oval to globose, hyaline, and measure from 2½ to 3½ microns in size.

On plate-cultures germination becomes apparent in about twenty-four hours. The conidia become swollen and put out from one to three slender germ-tubes which grow in a sinuous line from one or both ends of the conidium. A slight constriction and sometimes a septum separates the conidium from the base of the germ-tube. Often one or two vacuoles are present near the base of the largest germ-tube. The protoplasm is usually hyaline and homogeneous. After about forty-eight hours the threads appear above the agar in circular tufts. Many small and irregular vacuoles appear in the threads. Septa are sparingly and irregularly placed throughout the entire colony, and the branches are slightly constricted at the base. At the end of three days, the vacuoles become more thickly and regularly placed. The colonies by this time all appear above the surface of the agar, and some conidia are produced. The threads standing above the agar, bear short branches either in whorls, or placed in an opposite manner after the type of *Verticillium*. The conidia are borne either on the ends of these short branches or on short flask-shaped sterigmata grouped at the apex of a short branch. Those first produced cling to those next succeeding and so on until from two to eight conidia are collected forming a small spherical mass or sometimes an irregular chain. At the end of about four days, the threads usually spread over the surface of the plate in an even, flocculent layer, the colonies showing as points of denser growth. In case the conidia are thinly sown in making the dilution-culture, the threads confine themselves to the colonies and do not spread.

On potato a dense white and cottony growth appears, and soon spreads over the surface. A yellowish buff tinge is noticeable very early. A bright greenish lemon-yellow is noticeable where the mycelium comes in contact with the glass. Sporophores soon appear rising from the sides and upper portions of the potato slab. In one case a sporophore 5 mm. in diameter grew from the side of the potato to a height of 4 cm. in a nearly vertical direction (Figs. 99 and 100). At this distance from the base, it divid-

ed into fifteen smaller branches some of them $2\frac{1}{2}$ cm. in length and from $1\frac{1}{2}$ to mm. in diameter. All of these branches are covered with a dense, farinaceous yellowish-white coat composed of colorless conidia. Sometimes clavate branches are produced, from 2 to $3\frac{1}{2}$ mm. in diameter. Usually, however, the branches cling to the glass quite closely and are simple. A culture in an Ehrlmeyer-flask, having pieces of potato on the bottom to a depth of half an inch, grew much as in the case of a potato culture in a tube, except that the sporophores were in general, larger and much more flattened and clavate, owing to the increased supply of food and air. Some of them were $2\frac{1}{2}$ cm. long and over 1 cm. broad at the apex. They were about 4 mm. thick. The bases of the sporophores were tinged with lemon-yellow.

Several specimens of our common brown-and-black caterpillar, *Pyrrharcia isabella*, were dusted with conidia of this fungus and some of the caterpillars died. Two produced many yellowish sporophores from 2 to 3 mm. in length, in color closely resembling the original specimens. Unfortunately I have not been able to obtain a pure culture of any *Isaria*-like form from the specimens showing the sporophores. Specimens placed under like conditions but not dusted died, but did not show any signs of the fungus. The cause of the death of those exhibiting the fungus is therefore uncertain.

CORDYCEPS MELOLONTHAE (?) (Tul.) Sacc.

Conidial stage (?).—On Oct. 15th, 1895, Mr. Pieters found a white grub, the larva of *Lachnosterna*, lying on the surface of the ground in one of the forcing-houses. It was covered with short, stout sporophores, both simple and branched, the one near the anus being fully 5 mm. long. A growth 6 mm. in length bearing several short, spindle-shaped branches, issued from near the head. The grub was placed in damp sphagnum, to allow the development to proceed still further. After about two weeks the sporophores had attained a length of from 5 to 9 mm. and a diameter of 1 mm. sometimes expanded to 2 mm. On the sides of the sporophores are borne shining yellow disks, smooth and either plane or irregularly concave. These disks are composed of conidia held together by some viscid substance (Fig. 95). On removing the *Isaria*-sporophores, processes which are possibly the rud-

imentary stromata of *Cordyceps melolonthae* were seen. Several dilution cultures were made using the ordinary agar, but the fungus refused to grow, further than to germinate. Potato agar was used and the growth progressed slowly. After three days the conidia appeared swollen, and germination began by the production of one or two germ-tubes. Vacuoles usually appear in the conidium, and often at the base of the thread. In four days the threads grew to quite an extent, branching but little and showing no septa. The threads sometimes show swellings at their base. At the end of six days a few vacuoles and septa appeared. Many threads bear at their ends round or oval bodies (Figs. 58 and 60). The protoplasm in these is hyaline and homogeneous. Cylindrical conidia are borne in the agar after the manner of most of the *Isarias* studied. In order to get a pure culture on potato, a small piece of the agar containing growing mycelium was transferred to a slab of sterilized potato. The growth on potato either spreads evenly over the surface or grows in raised patches. The mycelium is dirty yellow in color where it touches the glass of the tube. Conidia are borne in dense patches on the surface of the felt. The production of conidia does not always take place for this species in artificial cultures.

ISARIA ANISOPLIAE (Metch.) Var. AMERICANA. n. v.

During the fall of 1893, about thirteen hundred wireworms were procured on which to experiment. They were chiefly larvae of *Agriotes mancus*. At Christmas time, a fungus was seen to be growing on them. It was provisionally identified as *Isaria anisopliae*, since the same fungus had previously been found by Mr. Slingerland in his experiments, and sent to Dr. Thaxter who identified it provisionally as *Metarrhizium anisopliae*.* The genus *Metarrhizium* has since been included under *Isaria*. Thaxter† says *Entomophthora anisopliae* of Metchnikoff‡ which attacks coleopterous larvae is perhaps an *Isaria*, the spores measuring 4.8 by 1.6 microns. It is placed by Sorokin as belonging to a genus of Basidiomycetes which he calls *Metarrhizium*."

* Bull No. 33 Cornell Exp. Station, p. 211.

† Mem. Bost. Soc. Nat. Hist., Vol. IV., No. 6, 1888.

‡ Zeitschr. d. K. Landwirth Gesell. of Neurussland, Odessa, 1879, pp. 21 to 50.

The larvae first became rigid, and somewhat dull in color. Soon a white growth of mycelium appeared usually near the head or between the sclerites. These small patches spread in a foliaceous stroma, which is white and grows out into the surrounding soil for a distance of 3 mm. or more. Sometimes it spreads very thin and grows to a distance of 5 or 6 mm., clinging to the bits of vegetable matter in the soil. This white stroma at length becomes colored a dull sage-green by the production of conidia. The conidia are from 5 to 7 microns in length and 3 microns in diameter. A dilution culture was made and germination became apparent in about twenty-four hours. The conidia become swollen, and the protoplasm becomes condensed at both ends of the oblong conidium. A slender germ-tube is put out at one or both ends of the conidium. After one day more, branching commences and by two days more, a few vacuoles appear. The branching growth increases steadily. In about six days the vacuoles become oval and regularly placed close together throughout the entire length of the mycelium. The colonies assume an irregular stellate form. A pure white growth of branching threads appears above the surface and after about ten days from the sowing conidia appear, borne in chains on heads of a pexnicillate type (Figs. 73, 74, and 75). These heads are borne on short pedicels situated at short intervals on the main filaments. The production of conidia is accompanied by the appearance of a decided sage-green color.

On potato, the growth shows itself after about six days, in finely radiate colonies at the points of inoculation. A greenish center soon appears and the white growth quickly spreads over the entire surface of the potato forming a dense felt. This soon turns green by the production of conidia. After a time, the conidia become densely packed in a layer 1 mm. or more in thickness. The chains of conidia still preserve their connection, and a columnar structure is thus produced which extends through the layer perpendicular to the surface of the potato. When a piece of this crust is broken, the fracture follows the chains of conidia showing transverse striations. The mycelium is slightly yellow at first, but later it becomes tinged with green.

A number of specimens of *Agriotes mancus* were rolled in conidia of *Isaria anisopliae* var. *americana* and placed in pots of earth

in a box of moist moss; but the specimens in the check cages also died, both having been infected with the disease before they were taken from the storage pots. Those artificially infected died in greater numbers, but the appearance of the disease in the check-cages makes it impossible to draw any positive conclusions. The wireworms contained in the storage cages all died before spring, and not a single click-beetle emerged. The spread of the disease was probably very much facilitated by searching for diseased specimens. In this way the soil, charged in places with conidia, became thoroughly mixed several times, thus carrying conidia to every part. The soil used was a sandy loam given to packing hard. To prevent this, a small amount of finely broken *Sphagnum* was mixed with it. Wherever this *Sphagnum* had not been thoroughly mixed, and remained in small masses, the disease was most prevalent. Larvae lying in or near such masses were almost sure to be attacked, the foliaceous stroma spread over the surface apparently deriving some nourishment therefrom. This suggests that possibly a loosening of the soil may be of some advantage where wireworms are abundant, especially if the disease be present. The cages in which they were confined were prepared as follows: about three hundred larvae were placed in an ordinary plant jar filled with soil prepared as described. Wheat and clover were sown on the surface and a large glass cylinder, such as is used for breeding insects, was placed over the jar, and its upper end closed with muslin. This jar was then placed in a second jar and the space of about an inch between was packed with moss, which was daily moistened. Enough moisture passed through the inner porous jar to supply the needs of the enclosed larvae.

ISARIA ANISOPLIAE (Metch.).*

A pure culture of a fungus working on wireworms, *Anisoplia*, was received, labeled *Isaria destructor* (Metch.), from France

*Krassilschik says (Bull. Sci. de Fr. et de la Bel. Jan.—Avr. 1893.—translation in French) and (Jour. Mycol, Vol. V. 1889, translation in English): That the genus *Metarrhizium* was established by Professor Sorokin for the Green Muscardine discovered by Metchnikoff upon the larvae of *Anisoplia austriaca* and first named by him *Entomophthora anisopliae*. But Metchnikoff since gave it the name of *Isaria destructor*. The name *Metarrhizium* was thus dropped, as the other members of the genus were imperfectly established. So if the first specific name is retained it would be *Isaria anisopliae* (Metch.)

communicated by Professor Alfred Giard. A dilution culture was made, and germination commenced before the end of one day. The conidia became swollen and from one to three germ-tubes were put out. During the succeeding growth, branching occurs freely. The diameter of the threads varies considerably, some being swollen and tapering (Figs. 63 and 64). They contain many vacuoles and granules. At the end of a week, some of the threads become inflated as shown in Figs. 65 and 66. The growth by this time appears above the agar. The growth is very much branched and closely packed, producing a very dense stellate or coarsely radiate growth. In two days more the colonies become tinged with green, by the production of conidia. The growth is so dense that it has been impossible to observe the conidia remaining attached to their sterigmata. Small pieces of the agar covered with conidia bearing mycelium, when placed in water under the microscope, show a fructification closely resembling that of *Penicillium*. The branched mycelium bears heads which are branched like *Penicillium* and which bear long chains of conidia, cylindrical in form and rounded at the ends. A refringent body is usually seen near each end. They measure about 3 microns in diameter, and from 6 to 7 microns in length. This mass of conidia forms a dense and compact covering for the mycelium.

On potato, the growth spreads over the surface of the potato from the points of inoculation, showing at the end of six days many elevated white points. A marked green color is visible in many places where the mycelium touches the glass; and where a felt is spread over the surface of the liquid, the entire growth becomes gradually colored a deep bottle-green by the production of conidia. Sometimes a narrow white border is left uncolored.

The growth is more compact and the color is darker than in the case of variety *americana*. The potato and liquid are tinged with green as well as the mycelium where it reaches the walls of the tube. The same columnar structure is seen in the crust of conidia as in the case of the var. *americana*.

Two cultures were started on the same day in Ehrlmeyer-flasks, filled with sterilized potato to the depth of three-fourths of an inch. One flask was inoculated with conidia of *Isaria anisopliæ* and the other with the variety *americana*. The variety

americana grew in a white, elevated, comparatively loose felt all over the surface of the potato. *Isaria anisopliæ* spread comparatively little, growing less vigorously, and in patches not covering more than one-fourth of the surface. The felt produced is much less elevated. After about two weeks the dull sage-green color appeared quite perceptibly in the variety *americana*. In *Isaria anisopliæ* the dark bottle-green color appears somewhat earlier. The growth of *Isaria anisopliæ* subsequently spreads over the entire surface of the potato. *Isaria anisopliæ* has a very dense, farinaceous appearance, while the variety has a looser cottony one. The color of *Isaria anisopliæ* is a deep brownish bottle-green, with the color of the mycelium distinctly green where it touches the glass. The color of the variety *americana* on the other hand is dull sage-green, with the mycelium buff yellow. These characters have been constant during a long series of cultures.

Krassilshik speaks of the coremium-form which sometimes appears on potato cultures. This is produced as follows: the branches of the mycelium bear in old cultures a dense crust of conidia having a columnar structure. Now small isolated patches of conidia-bearing mycelium often produce a small mass of conidia which cling together, producing small pieces of crust having this columnar structure, and sometimes showing the white mycelium beneath. This method of growth resembles *Coremium* quite closely but differs from the typical coremium method of growth. Professor Metchnikoff gives a short abstract* of his investigations on the fungus diseases of insects, during the year 1878, together with some more recent observations on the practical application of parasitic fungi for the destruction of injurious species. The original contribution is in the Russian language, "On the Diseases of the Larvæ of the Grain-beetle" (Odessa, 1878). Professor Metchnikoff found that the *Anisoplia austriaca* larva, which lives in the ground, is subject to several diseases, one of which he calls the "Green Muscardine," being produced by a parasitic fungus *Isaria destructor* (*anisopliæ*). The same fungus was also found to infest another beetle, *Cleonus punctiventris*, which is very injurious to beets.

* Zoologischer Anzeiger No. 47, pp. 44-47. (Riley, Am. Ent. Vol. III, p. 103, 1880.)

In the month of August, when the disease had not yet disappeared, about forty per cent. of the progeny of these latter beetles was destroyed. Of the experiments made to infest the *Anisoplia* larvæ with the spores of *Isaria*, several were successful, but in some cases the larvæ remained healthy for a long time. The same experiments made to infest the *Cleonus* larvæ were eminently successful. Of ninety larvæ, which for a short time were brought in contact with the spores, sixty-two died from Muscardine within twelve days. On the imago of the *Cleonus*, the Muscardine acts somewhat more slowly, but just as surely. Of fifty-eight beetles which he infected when fresh from the pupa, fifty-two died from Muscardine within fifteen days. From these and other experiments, Professor Metchnikoff concludes that *Isaria destructor* produces an epizootic disease of the insects mentioned, and believes it possible to produce the disease by sowing the spores.

ISARIA DENSA (Link.) Fries.

A pure culture of this fungus was obtained from Fribourg and Hesse, Paris. In describing the appearance of insects killed by the fungus, Giard says that the fungus appears in nature under very characteristic forms. In dry places the bodies of white grubs are hard and covered with a sparse white down which becomes pulverulent as the age becomes greater. In moist and clay soil the fungus sends out irregular prolongations from 5 to 6 cm. or even more in length. These prolongations cement the particles of earth and roots of vegetation. They often stretch from one mummy to another. He speaks of these prolongations as sporophores, comparing them to the aerial sporophores of the other *Isarias*. Both are sometimes sterile and sometimes fertile, and both are usually preceded by an enveloping stage. He ends by saying that the difference between the *Isaria* of the June-bug, and the other *Isarias* is of the same nature as the difference between an aerial stem and a rhizome in the *Phanerogamia*.

A dilution culture was made from the pure culture obtained from Paris, and the following characters of growth noted. Germination begins after about two days. The conidia become swollen and put out two or three germ-tubes (Fig. 23). Soon the oval vacuoles become abundant and a few septa appear. After

about four days the threads become full of large vacuoles (Fig. 25). The threads now become irregular in size. Some are large and inflated, the small ones are usually tapering and constricted at the base (Fig. 29). Elongate spores are thrown off in the agar, from the ends of short branches. The colonies are at this time finely radiate, and about 3 mm. in size. In a week's time many strands are to be seen, formed by several threads growing together for some distance. The growth appears above the agar in about ten days. The colonies continue to grow and branch until, at the end of about two weeks, they form even, fluffy, and strongly raised colonies. Soon after this, conidia are produced on flask-shaped sterigmata, which are either sessile or borne on short side branches. These sterigmata and the chains of conidia become crowded so as to form heads of some size like those of *Sporortrichum* (Figs. 26, 27, 28, and 30.)

On potato the growth starts from the points of inoculation and grows until, at the end of about a week, it appears as a lobulated white mass, strongly raised from the surface of the potato. The pure white mycelium contrasts strongly with the potato which is colored a deep purple by the fungus. After about two weeks the conidia give the growth a creamy, farinaceous appearance. Wherever the felty membrane resting on the surface of the liquid comes in contact with the glass tube, a delicate fringe of very fine white threads runs up which cling to the glass and preserve perfectly parallel courses. Cultures in half-litre Ehrlmeyer flasks showed exactly the same method of growth. Gelatine is colored a deep vinaceous purple when the fungus is grown in it.

On Oct. 31st, 1893, twenty larvæ of *Lachnosterna* were infected with *Isaria densa* in the following manner. Twenty grubs were placed in an earthen dish containing soil to the depth of about 1 cm. Half the contents of the tube just received from Fribourg and Hesse was mixed with half the white of an egg, and 15 cc. of water added. This was beaten and each grub carefully touched behind the head and along the sides with the liquid. The remainder of the liquid was poured over them and the dish and grubs covered with moist moss, and placed in a room of ordinary temperature. On Nov. 1st, the grubs were placed in two pots, ten in each, and covered with earth and moss full of conidia. Wheat was sown over the surface of the soil. On Nov. 14th, five were

dead ; two had just died and were very much swollen. On Nov. 20th, the swollen ones were pink. One of them was firm and apparently full of mycelium ; the other was attacked by bacteria and became a putrid mass. Several of the grubs were the centers of nodules of vegetable matter and soil, but the fungus binding them together proved to be a harmless *Mucor*. One grub was seen on Nov. 29th, which bore a white fungus on the surface. It was, together with the swollen one mentioned, rubbed on nine healthy grubs and placed with them in a new pot.

On Feb. 26, however, no effect was seen and the experiment was discontinued. The specimens in the check-cages, died at about the same rate, but none of them became swollen or pink in color. It is possible that the two grubs were attacked and killed by *Isaria* but it does not seem to act with the same virulence that is reported from Europe, possibly because of different climatic conditions and possibly also because of the difference in the host.

Perraud records experiments with *Botrytis tenella* (*Isaria densa*) in closed chambers. They were successful when small chambers were used, but when larger chambers were used, the experiments were less successful. He does not speak of its economic use.

Paul Sorauer* says that the results of his experiments show that the insects are rendered susceptible by being placed under unfavorable conditions, such as being provided with poor or insufficient food, or placed in a soil which is too moist. The latter is also favorable to the development of the fungus.

Dr. Jean Dufour in Lusanne† finds it very easy to produce the disease in specimens infected with the conidia, but finds it very difficult to spread the disease. He thinks that it is impossible for the grubs to spread it themselves to any useful degree. His experience is corroborated by Frank‡ who says, that the question is more difficult than it would appear. The difficulty does not consist in finding a parasite on the grub, but in spreading it.

M. E. Le Coeur|| infected also *Anthonomus pomorum* and *Chermalia brumata* with *Botrytis tenella*. Most of the pupae remained dead in the ground.

*Zeit. für Pflanzenkrankheiten, Vol. IV, p. 267.

†Zeit. für Pflanzenkrankheiten, Vol. III, p. 143. 1893.

‡Deutsche Landwirtschaftliche Presse, vom 19. Nov., 1892, p. 961.

||Bull. de la Soc. Mycol. de la Fr., Vol. VIII, p. 20, 1892.

My experiments were rendered very unsatisfactory because of what was apparently a bacterial disease, which broke out in the storage cages, as well as out of doors in places where grubs were abundant. The grubs showed small well-defined, irregularly-shaped patches of black, shiny skin, usually on the thorax at the bases of the legs, and often on the legs themselves. In such cases the legs dropped off as the disease advanced. Often the black patches appeared on the dorsal surface, just behind the head, and occasionally on any part of the body. These patches of blackened skin grew in size until sometimes the greater part of the insect was covered; but usually the grub died before the patches covered more than a small portion and subsequently it became a loose skin filled with a putrid mass. The grub became usually inactive soon after the first appearance of the patches. This disease apparently killed off the grubs under observation and became a general nuisance. A dilution culture from the diseased grubs was made and several species of bacteria obtained, but none in sufficient quantity to point to it as the cause of the disease. The fact that the grubs, placed as checks to the other experiments, were constantly dying rendered it impossible to determine by infection experiments, which was the pathogenic species. It is remarkable that the next season, that of 1894, was noticeable for the absence of June-bugs. Very few were seen at Ithaca. It is to be hoped that larvae showing the appearance of a disease such as described, may be found at some future time and the matter further investigated.

SPOROTRICHUM GLOBULIFERUM Speg.

This species usually appears in nature as a loose, white, cottony growth enveloping its insect host in fine filaments which bear at irregular but short intervals minute heads composed of conidia closely packed into a nearly spherical form. These heads are sessile and creamy white in color.

This should probably be regarded as a form species, the real species being in this stage, indistinguishable. In artificial cultures from the *Sporotrichum globuliferum* taken from nature, some of the forms progress to higher stages of development representing widely different species. These forms may some of them grow

differently in nature. Professor Forbes* describes and figures several insects on which true *Isaria*-sporophores were produced by infecting with a form found on a dead insect larva.

In this sense the form species *Sporotrichum globuliferum* is analagous to the old *Oidium erysiphoides*, a form species representing the conidial stage of various genera of the *Erysipheae*.

The typical form originally described as *Sporotrichum globuliferum* was probably identical with the following which was found on a carabid beetle in October 1894, by Mr. Pieters. The growth occurred in patches of conidia-covered mycelium from 1 to 1½ mm. in size. These patches are distributed irregularly over the head and ventral side of the body. The spherical conidia are borne in spherical heads on the sides of the long slender mycelial threads. This species seems to be the original *Sporotrichum globuliferum*† which was first found on Carabidae, and which appeared as in this case in patches on the surface and not in a dense felt as in the case of several other *Sporotrichums* hitherto identified as *globuliferum*.

A dilution culture was made in the usual way, and the following habit of growth observed: after one day the conidia become swollen and one or more germ-tubes are developed. These germ-tubes are strongly constricted at the base. The protoplasm is hyaline. In two days the threads become somewhat branched, with the branches also constricted at the base. Some vacuoles appear about this time. In three days cylindrical conidia are thrown off in the agar from the terminations of slender threads (Fig. 82). In about four days after sowing, the threads appear above the agar, forming radiate colonies which continue to enlarge until, at the end of a week, the colonies are 2 mm. in diameter, and strongly elevated, some being almost hemispherical. After this an even, loose growth usually spreads over the entire surface, connecting the colonies. On about the eighth day the threads become swollen and in many cases the protoplasm becomes concentrated in certain parts, leaving the other parts empty (Figs. 87 and 88). On about the thirteenth day the parts containing protoplasm germinate. They put out long slender tubes which grow as ordinary germ-tubes and produce cylindrical

*Bull. No. 38. Ag. Exp. Sta. Univ. of Ill., p. 33. Mar., 1895.

†Speg. Fungi. Argent. Pug., II. p. 42.

spores in the agar, as in the case of ordinary threads from aerial conidia. Sometimes a pair of spores will be produced and the parent thread will lengthen and leave these behind, producing another pair beyond. The protoplasm in these segments is nearly homogeneous, the walls being somewhat thickened. This shows how segments of mycelium may function as conidia, and suggests how the hyphal bodies of *Cordyceps clavulata* may be produced. After about four days from the sowing, conidia are borne outside of the agar. The sterigmata are terminal or sessile on the ends of short branches. The sterigmata are tipped with small spherical conidia (Figs. 84, 85, 86, and 90). The multiplication of these sterigmata and conidia results in a more or less compact head, spherical in form (Fig. 83).

A culture was made in an Ehlrmeyer-flask partially filled with pieces of sterilized potato. The growth quickly spreads over the entire surface. At the end of about four days, the potato was tinged purple in the near vicinity of the colonies. This color is soon obscured by the dense felt of mycelium which covers the surface, and which becomes strongly wrinkled as growth advances. No sporophores are produced but the surface is covered by a thick coating of creamy white conidia.

SPOROTRICHUM GLOBULIFERUM ON THE CHINCH-BUG.

In the fall of 1893, Chancellor Snow, of Kansas, kindly sent me a box of chinch-bugs covered with a growth of the so-called *Sporotrichum globuliferum* which has been used to such an extent against the ravages of these insects. A pure culture was obtained, but unfortunately the cultures were neglected and died before a careful study of its growth on potato and other media could be made. The growth on the bug is in the form of a dense felt, not exactly such as occurs in the typical form on the carabid beetle, but indistinguishable from it as far as microscopic appearance goes. Cultures in large flasks may prove it to be the same. A number of experiments were made attempting to produce the disease artificially on various insects. About one hundred live aphids, *Aphis brassicae*, were placed in a cage on a kohlrabbi, and thoroughly dusted with conidia. After about a month had passed, no effects were noticeable and the experiment was discontinued. Many specimens of wireworm, *Agriotes mancus*, were rolled in a Petrie-dish full of conidia and were then placed in moist soil.

None of them developed the fungus. Out of four carefully conducted experiments with white grubs, larvae of *Lachnosterna*, only one succeeded. Many grubs were dusted with conidia from potato cultures, or rolled in Petrie-dishes containing fruiting threads. Some were even touched with the infected bugs themselves. All of the grubs lived and showed no signs of the fungus. One however, of five grubs dusted with conidia obtained from a sterilized grub, on which the fungus had been grown, succumbed, and showed the disease in its characteristic form. From this a pure culture was obtained by means of a dilution culture. The experiments were on the whole unsuccessful, but as they were carried on with insects not the natural host of the fungus, they prove nothing as to its efficacy against the chinch-bug.

ISARIA VEXANS N. SP.

A larva of *Lachnosterna* found Apr. 7th, 1894, by Mr. M. V. Slingerland in a breeding-cage at the insectary, was completely covered with a felted white coat of *Sporotrichum globuliferum* bearing patches of creamy-white conidia. A microscopic examination showed the fructification to be exactly as in the case of the typical *Sporotrichum globuliferum*. A dilution culture was made, and germination became apparent at the end of one day. The development is as follows: the nearly spherical conidia become swollen and produce a germ-tube which grows in a sinuous line, branching occasionally and producing many long, cylindrical conidia in the agar. These are borne at the end of a filament and each spore is successively pushed aside by the one next produced, resulting usually in a cluster of spores placed side by side (Fig. 18). Branching soon commences and septa are often present just beyond the base of the branches. Small vacuoles appear, usually irregularly placed. At the end of about three days the growth appears above the agar, in loose, cottony filaments, each colony becoming circular in form, and finely radiate. After one more day, the conidia appear (Fig. 16.) Short sterigmata bear one or two conidia on short pedicels. These conidia increase in number and the sterigmata lengthen and multiply, until at the end of a week, large heads are formed (Fig. 20.) The threads anastomose

freely (Fig. 15.) In places where the colonies have been crowded, they assume a smaller stellate form instead of the ordinary circular form.

On potato, the growth spreads over the entire surface in a felted layer, afterwards becoming densely covered with a farinaceous, creamy-white layer composed of colorless conidia. *Isaria*-sporophores are often produced. In one tube are ten, ranging from 2 to 4 mm. in height. They are usually clavate in form being sometimes 3 mm. in diameter at the apex, tapering to 1 mm. at the base. On one side a long, pointed sporophore springs from a point near the glass, but free from it. It is slender, and measures 8 mm. in length, by about $1\frac{1}{2}$ mm. in diameter at the base. At another point, two about 1 mm. broad spring from the same base, where the potato touches the glass, and grow to a length of 1 cm. They are flattened and cling to the glass of the tube for their entire length. Wherever the mycelium touches the glass, it is seen to have a bright buff color.

A culture was started in a half-liter Ehlrmeyer-flask, having about 4 cm. in depth of potato in small pieces at the bottom. In about two weeks a growth spread over the entire surface. The potato was colored a distinct purple, considerably less intense than in the case of *Isaria densa*. After about twenty days the entire surface became marked with a creamy-white covering composed of conidia. In many places there appeared crowded radiating growths of threads, spherical in form, having a creamy-white color and a velvety appearance. The buff color is usually more pronounced at the base and center of such spherical growths; the growth is also more dense at these places. It five or six days more the velvety pile collapses gradually, and from three to fifteen cylindrical processes are produced in its place. These present a color more intensely creamy than the velvet balls from which they spring. The cylindrical sporophores seem to protrude through the sphere at the same time that the pile collapses. They develop into long, slender, erect and usually clavate sporophores generally simple though sometimes branched. They occasionally reach the length of $2\frac{1}{2}$ cm. The color of the mycelium, where it touches the glass, is orange. These characters show this form to be an *Isaria*, and the name *Isaria vexans* is here proposed for it.

•

This method of growing fungi in flasks, allows the fungus to reach a maturity that is impossible in the smaller tubes, because of the insufficient supply of moisture and nutriment.

Infection experiments were made with four species of insects. Twenty-four larvæ of our common cabbage-butterfly, *Pieris rapæ*, were dusted with conidia obtained from a potato culture. After five days, four of the larvæ were dead, and colored a deep vinaceous purple. In places were patches of a white felty growth of the mycelium. After five days more, the remainder of the larvæ had pupated, excepting one which soon died. After seven days more, three out of the original twenty-four emerged, all the rest having succumbed. In the case of pupæ, the disease invariably starts from the wing-pads. Its presence is indicated by a deep purple color which spreads from the wing-pads over the entire body. This purple color is also noted by Professor Forbes* who finds cabbage-worms are turned purple when attacked by the fungus used against the chinch-bug. The death of the insect may not occur until the disease has become well advanced. The pupæ sometimes move spasmodically when irritated, even after the color has spread all over the pads and to some adjacent parts of the thorax. After the death of the insect, the mycelium appears as a close felt spreading over the entire surface of the body. All the specimens in the check cages remained unaffected and well throughout, all of them emerging as adults. A dilution culture proved the fungus to be the same as that originally used for infection.

On August 18, 1894, about forty Harlequin Milkweed caterpillars, *Cynia egle*, were dusted with conidia of the fungus. After five weeks no effects were visible. The caterpillars grew and eventually pupated. The pupæ did not exhibit any traces of the fungus.

Two large cages of our common Fall Web-worm, *Hyphantria cunea*, were dusted with conidia obtained from a potato culture. After five weeks no results were visible. Eventually they nearly all pupated, presenting no traces of the fungus.

On Aug. 22, 1894, thirty caterpillars of the Red-humped Apple-worm, *Oedemasia concinna*, were dusted with conidia obtained from a potato culture. After about a month, eight caterpillars

* Bull No. 38, Ag. Exp. Sta. of the Univ. of Ill., 1895, p. 33 and 43-44:

and two pupae were found to be dead and completely covered with a characteristic felt which exhibited the ordinary mode of growth and fruiting.

A cage containing caterpillars of *Melitea phaeon* stood near the cage of infected cabbage-worms, and three of these became accidentally infested and died, producing the characteristic growth.

The cages used in the experiments described, were ordinary glass cylinders closed at the upper end with muslin. The air in them was slightly, if at all, more humid than that outside.

A culture tube, in which Mr. Pieters was growing a pyrenomycetous fungus, was left open for a short time and a number of our small red ants, troublesome in the laboratory, entered, probably bringing the conidia of this fungus with them on their bodies. The cotton plug of the culture-tube was reinserted and the ants left to their fate. They died in about a week and in due time, became covered with a white growth of the fungus, the conditions being favorable to its development. The growth was in this case loose and fluffy. A dilution culture and pure cultures, in flasks of potato, proved it to be the species in question.

SPOROTRICHUM GLOBULIFERUM ON *Vespa* sp. (Probably
Isaria sp.)

On Oct. 29, 1894, Mr. Pieters found a specimen of *Vespa* sp. almost covered with a thick felted growth of a white fungus. A microscopic examination failed to reveal any characters which would differentiate it from *Sporotrichum globuliferum*. The heads of small spherical conidia were borne on threads exactly as in the case of the typical specimens. A dilution culture was made and the following habit of growth noted: germination becomes apparent after about twenty-four hours. One or two germ-tubes are put forth which grow in a sinuous line and soon begin to branch, throwing off a great number of cylindrical spores in the agar. The protoplasm is hyaline. There are very few vacuoles at first, but they soon appear, becoming plentiful at the end of three days. In four days many of the cylindrical spores germinate, putting out slender tubes and growing as in the case of ordinary conidia. These cylindrical spores may be broadly oval or long and slender. They are present in greatest numbers in the places of crowded growth. The threads emerge from the agar on about the fifth day. A loose, fluffy, strongly elevated growth appears, which soon becomes crowded with conidia. The threads

bear many short sterigmata at irregular intervals and irregularly placed, often whorled. These sterigmata bear from one to six oval, nearly spherical conidia about $1\frac{3}{4}$ to $2\frac{1}{2}$ microns in size. The multiplication of these sterigmata and conidia soon forms an irregular or spherical head. The threads anastomose freely. After ten days the colonies attain the size of 2 cm. in diameter, where they are not crowded, the central two-thirds being colored white by conidia, the outer margin being finely radiate in the agar.

On potato, the growth spreads evenly and loosely over the surface. A dense, firm web is formed over the surface of the liquid. At the end of six days the mycelium is creamy yellow where it touches the glass. Later it turns buff, and sometimes almost red, at the surface of the liquid. The white aerial mycelium sometimes bears Isaria-sporophores, formed by the interlacing of threads, 2 cm. or more in length. Cultures in Ehrlmeyer-flasks grow the same as in tubes, except that the potato is colored slightly purple in the near vicinity of the colonies, after about the seventh day. This color usually fades out soon. Many strong sporophores are produced all over the surface of the potato, some of them measuring 2 to 3 cm. in length and 1 cm. in breadth. They are usually flattened.

SPOROTRICHUM MINIMUM Speg.

On Dec. 18, 1894, Mr. Martin, a student in the University, found a large black ant, *Camponotus*, under the bark of a decaying log. The insect was covered with a growth of white mycelium, but no conidia were visible. It was placed in a moist-chamber for a few days, when great numbers of small spherical conidia made their appearance, borne in loose branching heads identical with those produced in artificial cultures. Nearly the entire insect was covered with a dense, white, felted growth of mycelium.

On Dec. 26, a dilution culture was made. After two days, the conidia become swollen and one or two germ-tubes are put out which branch freely (Fig. 34). The threads are continuous and the protoplasm is hyaline. Cylindrical spores, either short and broad, or elongated, are thrown off in the agar (Figs. 35 and 36). By the end of three days, the threads begin to emerge from the sur-

face of the agar. Many septa appear now irregularly placed. The conidia appear on about the eighth day. The threads spread loosely over the surface of the agar, and the short, lateral or terminal branches bear flask-shaped sterigmata, either singly or in groups. The macroscopic growth on the plate is at first coarsely stellate, afterward becoming finely radiate and more dense. A small, dense, conidia-bearing mass of mycelium is usually formed at the center of the colony, and a looser tangle of threads bearing conidia usually covers the colony, sometimes spreading over the entire plate. A good deal of variation is noticeable. The periphery of the colony is usually fringed with a fine feathery growth in the agar, composed of either curved or straight strands, made up of several filaments. The sterigmata are flask-shaped and bear at the apex a single conidium or more often three to six conidia collected into a compact ball, probably held together by some viscid substance which prevents their forming chains and draws back the ones first produced causing them to adhere at the sides of the later conidia.

On potato the growth spreads very slowly over the surface, forming a close felt, white, and not strongly raised from the surface of the potato. The mycelium is yellow where it touches the glass. No *Isaria*-sporophores are produced.

Mr. Walsh* early suggested the use of entomogenous fungi as insecticides. Since that time there have been many experiments, some of which seem to show the subject to be of considerable economic importance. Among those who have done the most toward testing the value of fungi as insecticides, are Professor Giard, in France, who has carried on many experiments with *Isaria densa*, and several other species. From the reports of Chancellor Snow, it would seem that *Sporotrichum globuliferum* might be used effectively against the chinch-bug. Professor S. A. Forbes has worked on many forms in Illinois, but has paid especial attention to *Sporotrichum globuliferum* and the chinch-bug. Professor Roland Thaxter has carried on careful experiments with the Entomophthorae although usually obtaining negative results. M. J. Perraud and M. Paul Soraur as well as Dr. Dufour and M. Le Coeur have experimented with *Isaria densa* but they have usually obtained negative results.

* Practical Entomologist, Vol. 2, p. 116.

BIBLIOGRAPHY.

ATKINSON, G. F. Artificial Cultures of an Entomogenous Fungus. Bot. Gaz., Vol. XIX., pp. 129-145, 3 pl., 1894.

BROUGNIART, M. C. Note on *Lachnidium acridiorum* Giard. Annals, Soc. Ent. de Fr., Seance du 24, fevrier, 1892.

BRUNER, L. and BARBER, H. G. Chinch-bugs. Bull. Ag. Sta. Univ. Neb., Article VIII., pp. 143-161.

BURRILL, T. J. White-grub in Illinois. Cultivator and Country Gentleman, 27 Aug., 1874, Vol. 39.

CIST, JACOB. Notice of the Melolontha or May-bug. Amer. Jour. Sci. and Arts. Aug., 1824, pp. 269-271, pl. 4.

COOKE, M. C. The Pyrenomycetous Fungi of the U. S. Bull. Buff. Soc. Nat. Sci., 1877, Vol. 3, Feb., pp. 189-192. Jul. pp. 193-202.

DUFOUR, JEAN. Einige Versuche mit *Botrytis tenella* zur Bekämpfung der Maikäferlarven Zeitschrift für Pflanzenkrankheiten. Vol. II., p. 2, 1892.

DUFOUR, JEAN. Nochmals über *Botrytis tenella*, zeit. für Pflanzenkrankheiten. Vol III., pp. 143, 1893.

FARLOWE, W. G. Description of *Botrytis rileyi*. Rept. U. S. Dept. Ag., 1883, p. 121.

FORBES, S. A. On a Contagious Disease of Caterpillars. Trans. Ill. Hort. Soc., 1883, p. 29.

FORBES, S. A. Memoranda with regard to Contagious Diseases of Caterpillars and the possibility of using the virus of the same for economic purposes. Amer. Nat., Vol. XVII., pp. 1169-1170. Nov., 1883; and Canad. Ent., Vol. XV., pp. 171-172. Sept., 1883.

FORBES, S. A. On the Present State of our Knowledge concerning Insect Diseases. Psyche, Vol. V., 1888-90, pp. 3-12. Bibliog., pp. 15-22.

FORBES, S. A. *Sporotrichum globuliferum* for the White grub. 18th Rept. Ill. State Entomologist for the year 1891-2, pp. 126-127, and pp. 133-137.

FORBES, S. A. Trans. Dept. Ag. of Ill., 1893. Vol. XXXI. pp. 133-7.

FORBES, S. A. Experiments with the Muscardine Disease of the Chinch-bug, and Barrier Method for Destruction of that Insect. Bull. No. 38., Univ. of Ill. Ag. Exp. Sta.

FRIES. Systematic Mycology, III, p. 419, 1832.

FYLES, T. W. Fungous Disease upon the Cut-worms. 15th Ann. Rept. Ent. Soc. of Ont., 1885, pp. 1-23.

GIARD, A. Sur quelques Typen remarquables de Champignon Entomophytes. Bull. Sci. de la Fr., et de la Bel., 1889, pp. 197-224, 3 pl.

GIARD, A. L. *Isaria* parasite de la larve du Hanneton. Compt. Rend. Acad. Sci., 1, juin, 1891.

GIARD, A. M. Sur l'*Isaria densa*, Link. Parasite du Ver blanc. Comptes Rendus des Seances de l'Acad. des Sci. 3, aout., 1891.

GIARD, A. Sur le Champignon parasite des Criquets pelerins. Comptes Rendus de l'Acad. des Sci., 3, aout, 1891.

GIARD, A. Le Criquet pelerin *Schistocerca peregrina* et son Cryptogame parasite *Lachnidium acridiorum*. Compt. Rend. Soc., Biol. 9. jan., 1892.

GIARD, A. Nouvelles etudes sur le *Lachnidium acridiorum* Gd. Champignon du Criquet pelerin. Revue generale de Bot. T. IV, No. 47. 15 Nov., 1892, p. 449.

GIARD, A. L'*Isaria densa* (Link), Fries. Champignon parasite du Hanneton comune. Bull. Sci. de la Fr. et de la Bel., 5. mai, 1893.

GLOVER, TOWNSEND. Note on a disease of caterpillar. Rept. U. S. Comm. of Pat's for 1855, p. 91.

HAGEN, H. A. *Cordyceps ravennelii* on the larvæ of *Ptylophaga*. Can. Ent., May, 1880. Vol. XII., p. 89.

HALSEY, A. Remarks on certain Entozoical Fungi. Ann. Lyceum Nat. Hist., N. Y., Apr., 1824.

LECONTE, J. L. Hints for the Promotion of Economic Entomology. Proc. Amer. Assoc. Adv. Sci. for 1873-1874. Vol. XXII, pt. 2, pp. 10-22.

LECONTE, J. L. Fungoid Diseases of Insects. Can. Ent., July, 1880. Vol. XII., pp. 126-128.

LECOEUR, E. *Le Botrytis tenella*, parasite de l'Anthonome et de la Cheimatobie. Bull. de la Soc. Mycol. de Fr. Vol. III., p. 20, 1892.

LEIDY, J. Description of new genera and species of Entophyta in *Julus* and *Passalus*. Proc. Acad. Nat. Sci. Philad., 25 Dec., 1849, Vol. IV., pp. 249-250.

LEIDY, J. *Cicada septendecim* affected by a fungus. Proc. Acad. Nat. Sci. Philad., 1851, Vol. V., p. 255.

LEIDY, J. Remarks upon Parasitism of Insects. Proc. Acad. Nat. Sci., Philad., 1851. Vol. 5, p. 204, 210-211.

LEIDY, J. Ant infested with fungus. Proc. Acad. Nat. Sci., Philad., Vol. XXXV., 1 Jan., 1884, p. 9.

LESLEY. The destruction of Insect Pests. Nature, Vol. XXI., pp. 447-448.

LINTNER, J. A. The Seventeen-year Locust destroyed by a Fungus. 2d Ann. Rept. N. Y. State Entomologist. 1885, pp. 178-179.

LINTNER, J. A. The White grub of the May-beetle. Bull. N. Y. State Mus. of Nat. Hist., No. 5, Nov. 1888, pp. 20-21.

LUGGER, OTTO. Fungi which kill Insects. Ann. Rept. Ag. Univ. of Minn., 1888, pp. 300-392; also Biennial Rept. Bd. of Regents of Univ. of Minn., Sept. 1, 1888, pp. 355-356, and 380-394.

LUGGER, OTTO. The Chinch-bug. Bull. 37, Univ. of Minn. Ag. Exp. Sta., Dec., 1894.

MACMILLAN, C. Note on a Minnesota species of *Isaria* and an attendant *Pachybasium*. Jour. Mycol., 1890-91, Vol. VI., pp. 75-76.

NOEL, P. *Botrytis tenella*. Bull. du Laboratoire regional d'Entomologie Agricole, Rouen., Jour. de l'Agriculture, 1892.

PECK, C. H. Description of *Torrubia clavulata*. Rept. of Botanist in 28th Ann. Rept. N. Y. State Mus. Nat. Hist. for 1874, p. 70.

PECK, C. H. Fungi as Insect Destroyers. Amer. Nat., May, 1880, Vol. XIV., pp. 363-364.

PECK, C. H. Rept. of Botanist, in 31st Ann. Rept. N. Y. State Mus. Nat. Hist., p. 19; also Hedwigia, Oct., 1881. Vol. XX., p. 154.

PERSOON, C. H. *Sporotrichum densum*. Mycologia Europaea, Vol. I., p. 75, 1822.

PRILLIEUX et DELACROIX. Le Parasite de la larve du Haneton. Compte Rendu de l'Acad de Sci., 11 mai., 1895.

RATZBURG, J. T. C. Fungoid parasitism of Insects. Proc. Bost. Soc. Nat. Hist., Apr., 1869, Vol. XII., p. 381.

RILEY, C. V. The White grub. 1st Ann. Rept. of the State Entomologist of Mo., 1869, pp. 156-159, figs. 88-89.

RILEY, C. V. The Periodical Cicada. 1st Ann. Rept. of the State Entomologist of Mo., 1869, pp. 18-42.

RILEY, C. V. The unadorned Tiphia or White grub Parasite, *Tiphia inornata*, Say. 6th Ann. Rept. State Entomologist of Mo., 1874, pp. 123-126, figs. 34-35.

RILEY, C. V. Fungus Diseases of Insects. Amer. Ent., Apr. 1880, Vol. III., p. 103.

RILEY, C. V. The White grub Fungus. Amer. Ent., June, 1880, Vol. III., pp. 137-140, figs. 53-55.

SACCARDO. Fungi Ital., 1884.

SACCARDO. Sylloge fungorum, 1886.

SAUNDERS, W. The Annual Address of the President of the Entomological Society of Ontario, Can. Ent., Oct., 1878, Vol. X., p. 183.

SAUNDERS, W. The Annual Address of the President of the Entomological Society of Ontario, Can. Ent., Oct., 1879, Vol. XI., pp. 186-187.

SAUVAGEAN, C. and PERRAUD, J. Sur un Champignon parasite de la Cochylis. Comptes Rendu de l'Acad. des Sci., 17, jul., 1893.

SHÖYEN, W. M. Ueber einige Insectenschädlinge der Laub und Nadelbaume in Norwegen. Zeits. für Pflanzenkrankheiten, Vol. III., p. 266.

SCHWARZ, E. A. Disease of *Chauliognathus* larvæ. Amer. Ent., Nov., 1880, Vol. III., p. 277.

SEAMON, W. H. Some Remarks on Fungi considered as Insecticides. Amer. Ent., Feb., 1880, Vol. III., pp. 40-41.

SHIMER, H. Notes on *Micropus (Lygaeus) leucopterus*, "The Chinch-bug." With an account of the great epidemic disease among Insects. Proc. Acad. Nat. Sci. Philad., May, 1867, Vol. XIX., pp. 75-80.

SNOW, F. H. Contagious diseases of the Chinch-bug. 1st Ann. Rept. of the Director of the Exp. Sta., Univ. of Kan., pp. 1-319, 3 pl. and a map, 1891.

SNOW, F. H. Contagious diseases of the Chinch-bug. 2d Ann. Rept. of the Director of the Exp. Sta., Univ. of Kan., 1892, pp. 1-56.

SORAUER, P. Ein Versuch mit *Botrytis tenella* behufs Vernichtung der Engerlinge. Zeits. für Pflanzenkrankheiten, Vol. IV., p. 267.

SOROKIN, N. Centralblatt für Bacteriologie und Parasitenkunde, 1888. Bd. IV., n. 21, pp. 644-647.

SOUTHWORTH, E. A. Review of Bulletin Science de la France et de la Belgique, Janvier and Avril, 1889. (By Giard.) Jour. Mycol., Vol. II., 1889.

SOUTHWORTH, E. A. Review on some remarkable types of Entomogenous Fungi. (By Giard.) Jour. Mycol., 1890-91, Vol. VI., pp. 38-39.

THAXTER, R. The Entomophthoræ of the United States. Mem. Bost. Soc. Nat. Hist., Vol. IV., no. 6, Apr., 1888.

THUMAN, Baron F. Pilze auf Borkenkäferholz. Flora., 1875, pp. 237-240.

TULASNE, L. R. C. Selecta Fungorum Carpologia. Paris, 1865, Vol. III., pp. 4-24, pl. 1-3.

VORCE, C. M. Wholesale destruction of Acari by a Fungus. Proc. Amer. Soc. Mic., 1881, Vol. IV., pp. 49-50.

WALSH, B. D. A Plant growing out of a Fungus. Practical Entomol., Aug.-Sept., 1867, Vol. II., p. 116.

WALSH, B. D. and RILEY, C. V. Fungoid Growths. Amer. Ent., Jan., 1869, Vol. I., pp. 91-92.

WEBSTER. Vegetal Parasitism among Insects. Jour. Hort. Soc. of Columbia, Ohio, Apr., 1894, pp. 1-18, pl. 3-5.

ZABRISKIE, J. L. A Caterpillar Fungus from New Zealand and some related Species from the United States. Jour. N. Y. Micros. Soc., Apr., 1885, Vol. I., pp. 89-94, figs. 1-6.

ZOPF. Die Pilze, p. 459.

EXPLANATION OF PLATES.

Cordyceps clavulata. Plates I and II.

1. Hyphal bodies from *Lecanium* on Maple.
2. Hyphal bodies in agar after three days.
3. Hyphal bodies germinating in the body of a coccid.
4. Hyphal bodies from *Lecanium fletcheri*.
5. Hyphal bodies from *L. fletcheri* in agar after one day.
6. Mycelium from Fig. 5, after five days.

7. Mycelium from Fig. 5, after two days.
8. Hyphal bodies from *Lecanium* on Maple, after two days.
9. Threads and sterigmata bearing conidia from cultures.
10. Threads and sterigmata bearing conidia from coccid.
11. Asci of perfect form.
12. Spores of perfect form.
13. Germination of ascospores in agar after two days.
14. Longisection of head of perfect stage.

Isaria vexans n. sp. Plate III.

15. Threads anastomosing after one week.
16. The first conidia, four days.
17. Germination of conidia in agar, one day.
18. Cylindrical spores in the agar, two days.
19. The same as Fig. 16.
20. Heads of conidia after one week.

Cordyceps militaris var. Plate III.

21. Ascus.
22. Single spore and segments. Plate III.

Isaria densa.

23. Germination of conidia in agar, two days.
24. Germination of conidia in agar, three days.
25. Threads after four days.
- 26, 27, and 28. Sterigmata and conidia after two weeks.
29. Swollen threads after six days.
30. The same as Fig. 27.

Isaria farinosa. Plate IV.

31. Germination of conidia after one day.
32. Colony after two days.
33. Threads bearing conidia, after six days.

Sporotrichum minimum. Plate IV.

34. Germination of conidia, after two days.
35. Cylindrical spores borne in the agar, after two days.
36. The same after three days.
- 37 and 38. Threads bearing conidia after eight days.

Cordyceps militaris. Plate V.

39. Asci.
40. Segment of spore.
41. Connected segments of spores in agar, twenty hours.

42, 43, and 44. Spore-segments germinating after forty hours.

45, and 46. Colonies after three days.

47-51. Threads bearing conidia, six days after sowing.

52 and 53. Immature perithecia in potato cultures.

Cordyceps melolonthæ (?) Plate VI.

54. Conidia.

55. Conidia germinating, after three days.

56, 57, 58, 59. Portions of colonies showing oval bodies in the agar.

60. Oval body detached.

61. Colony after four days.

Isaris anisopliæ. Plate VI.

62. Conidia germinating in agar, after one day.

63. Conidia germinating in agar, after two days.

64. Colonies after three days.

65 and 66. Threads after six days.

67 and 68. Conidia-bearing heads and conidia.

Isaria anisopliæ, var. *americana*. Plate VII.

69. Conidia in agar.

70. Conidia germinating in agar, after forty-eight hours.

71. Colony after three days.

72. Colony after seven days.

73, 74, and 75. Heads bearing conidia.

Isaria tenuipes. Plate VII.

76. Conidia germinating after twenty-four hours.

77. Colony after two days.

78 and 79. Threads bearing conidia after four days.

Sporotrichum globuliferum, from Carabid beetle. Plate VIII.

80. Conidia germinating after one day.

81. Colony after two days.

82. Cylindrical spores in the agar, three days.

83, 84, 85, and 86. Threads bearing conidia.

87, 88, and 89. Segments of threads in agar germinating after thirteen days.

90. The same as Fig. 84.

Isaria farinosa. Plate IX.

91. On Arctiid larva. x 2.

Cordyceps militaris. Plate IX.

92. On unknown insect. x $1\frac{1}{2}$.

Isaria farinosa. Plate IX.

93. Depauperate form on insect eggs.

Sporotrichum globuliferum (*Isaria* sp. ?) Plate IX.

94. On *Vespa*. x 2.

Cordyceps melolonthæ, conidial stage. Plate X.

95. On White grub.

Isaria arachnophila. Plate X.

96. On unknown spider.

Cordyceps clavulata. Plate X.

97. Perfect stage. x 2.

98. *Isaria* stage. x 2.

Isaria tenuipes. Plate XI.

99 and 100. Two views of the same culture on potatoes.

Isaria vexans. Plate XI.

101. Culture in flask on potato.

The drawings of the development of the forms figured were made with a camera-lucida and are, with the exception of Figs. 14, 52, and 53, magnified thirty-three times more than the scale which is ruled to one-tenth of a millimeter. Figs. 52 and 53 are magnified five times more than the scale.

RUFUS HIRAM PETTIT.

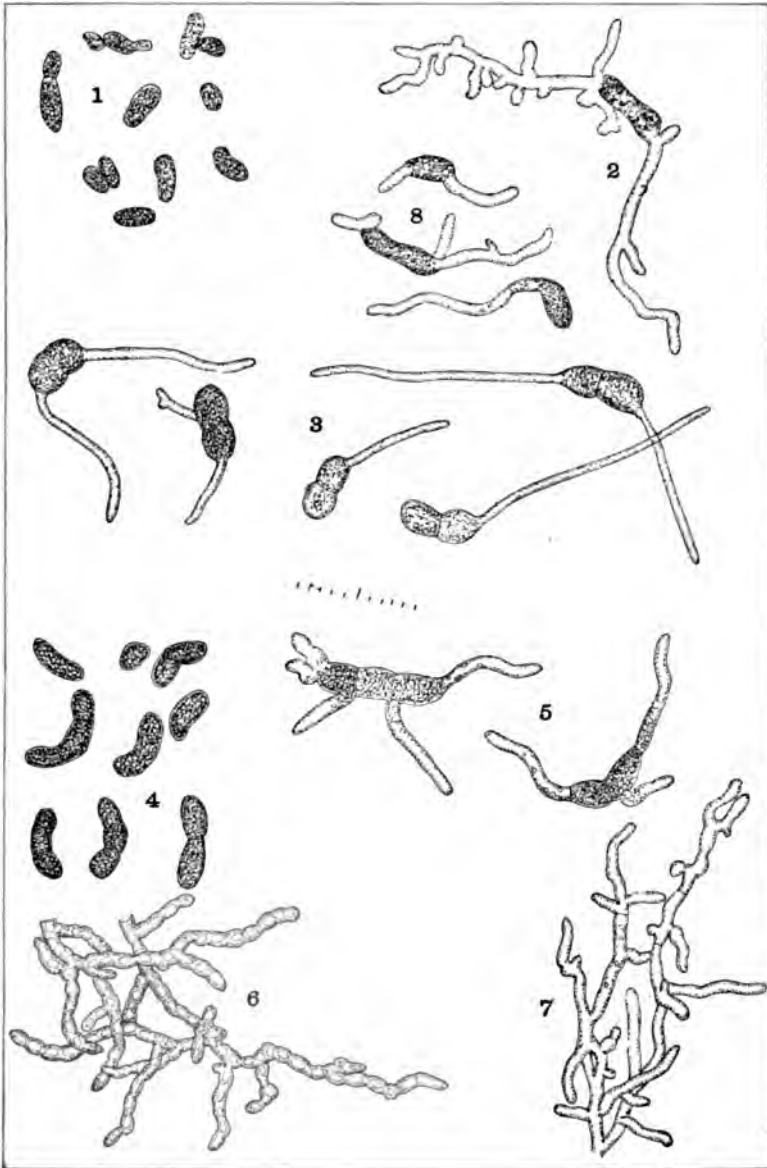


PLATE I.—*Cordyceps clavulata*.

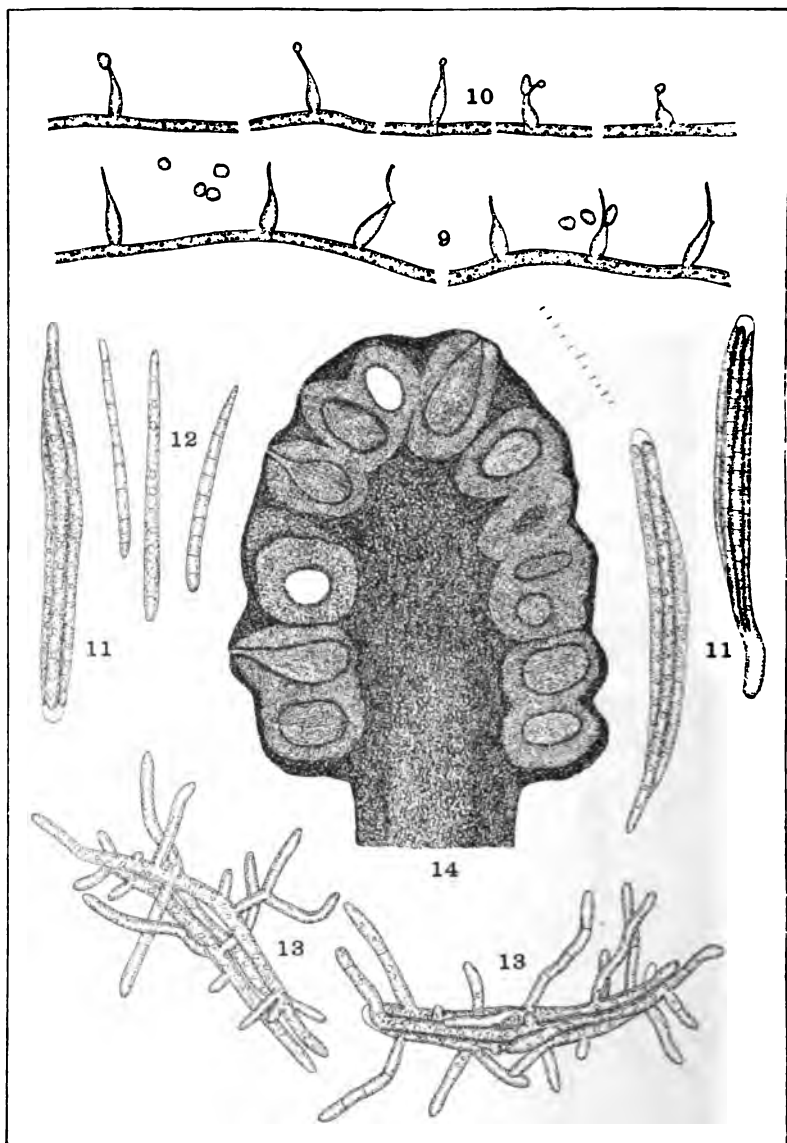


PLATE II.—*Cordyceps clavulata*.

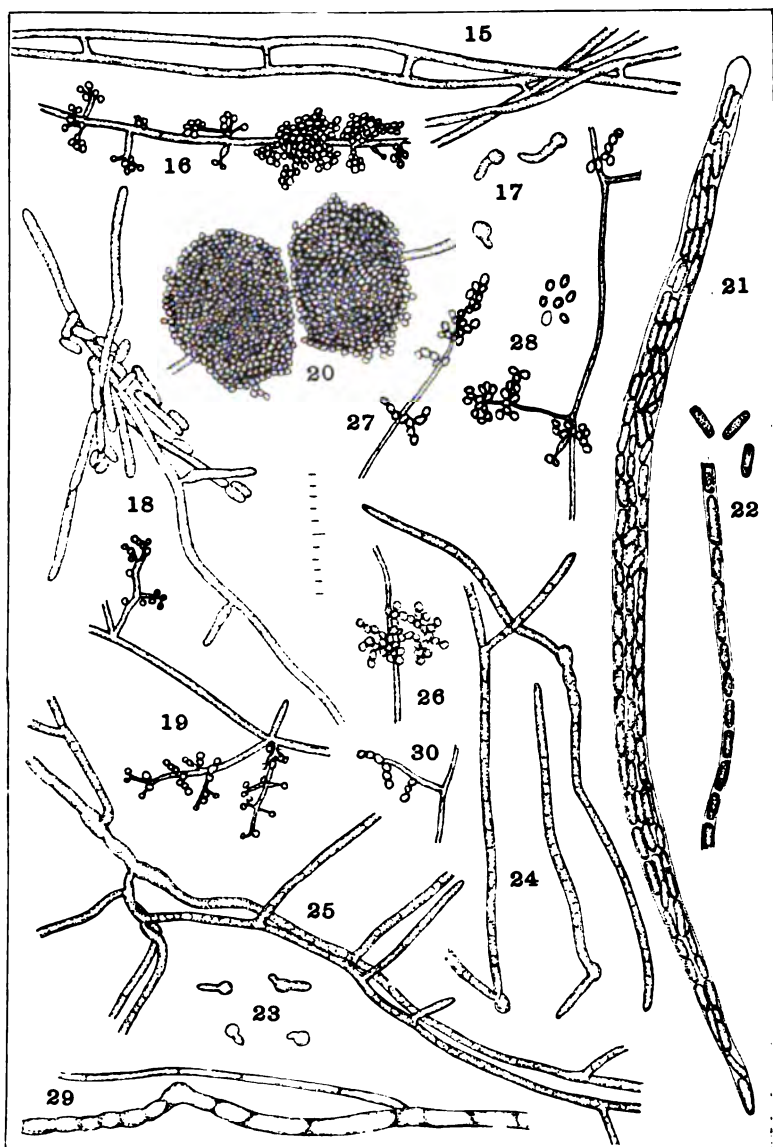


PLATE III.—15-20, *Isaria vexans*; 21, 22, *Cordyceps militaris* var; 23-30, *Isaria densa*.

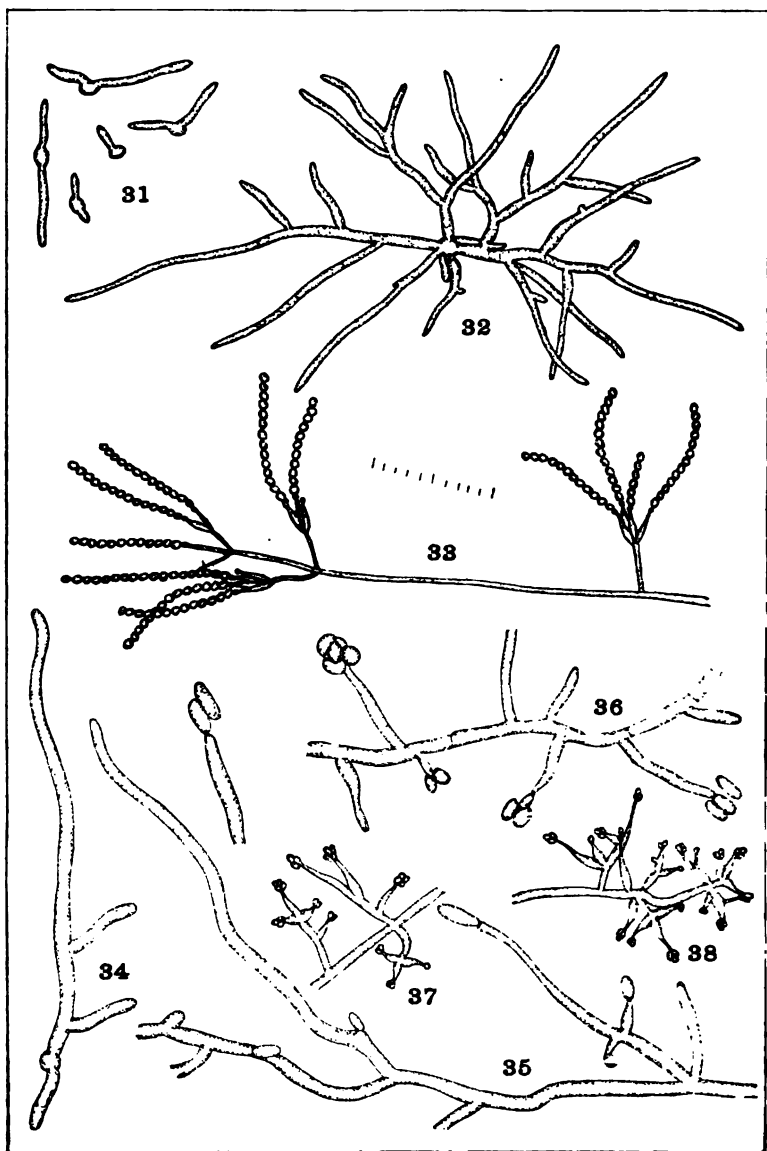


PLATE IV.—31-33, *Isaria farinosa*; 34-38, *Sporotrichum minimum*.

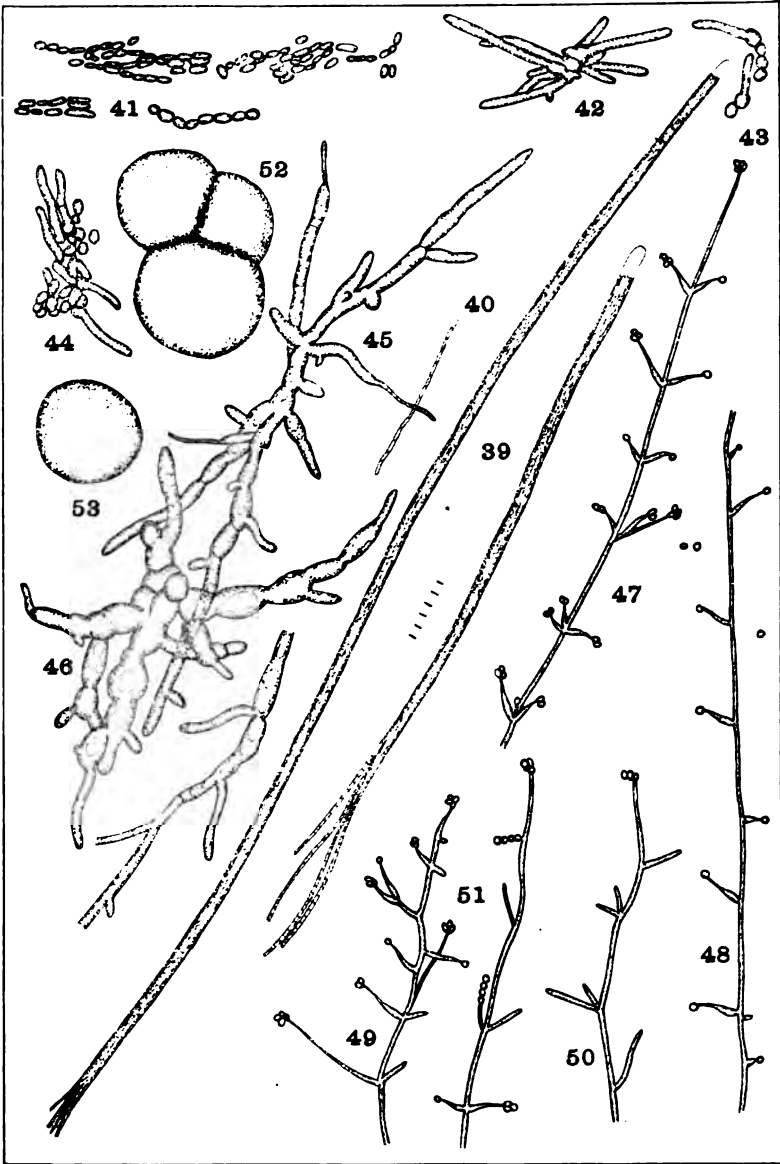


PLATE V.—39-53, *Cordyceps militaris*.

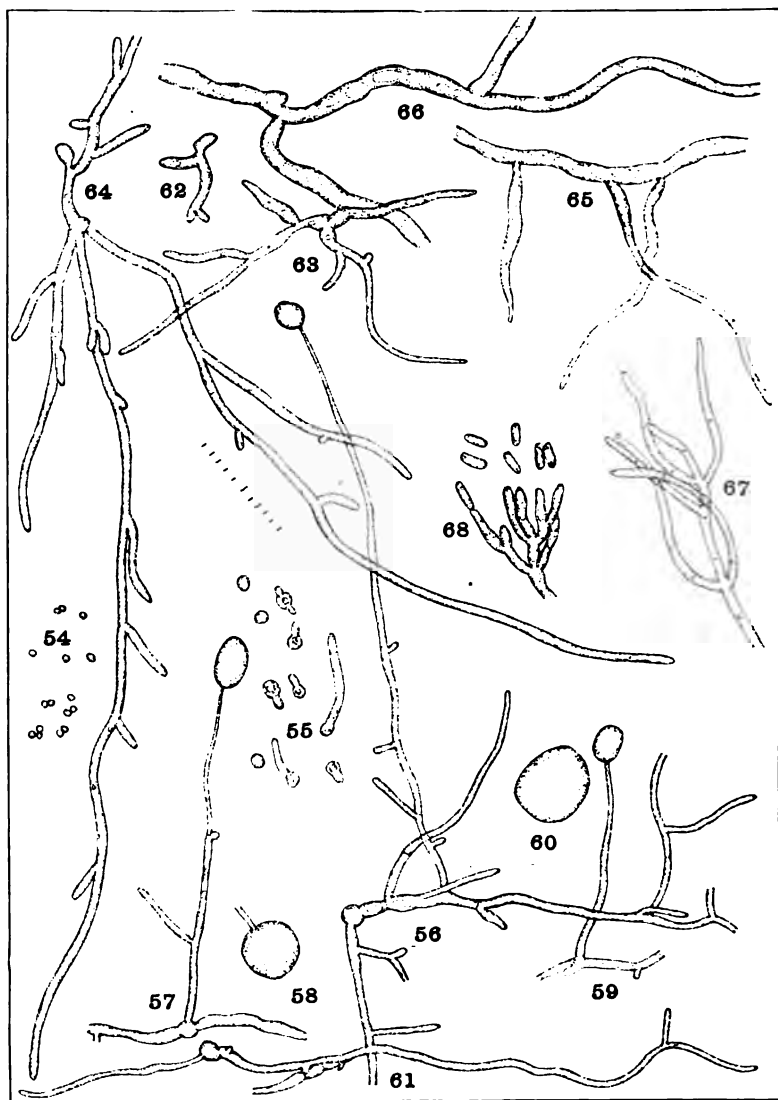


PLATE VI.—54-61, *Cordyceps melolonthæ* ?; 62-68, *Isaria anisopliæ*.

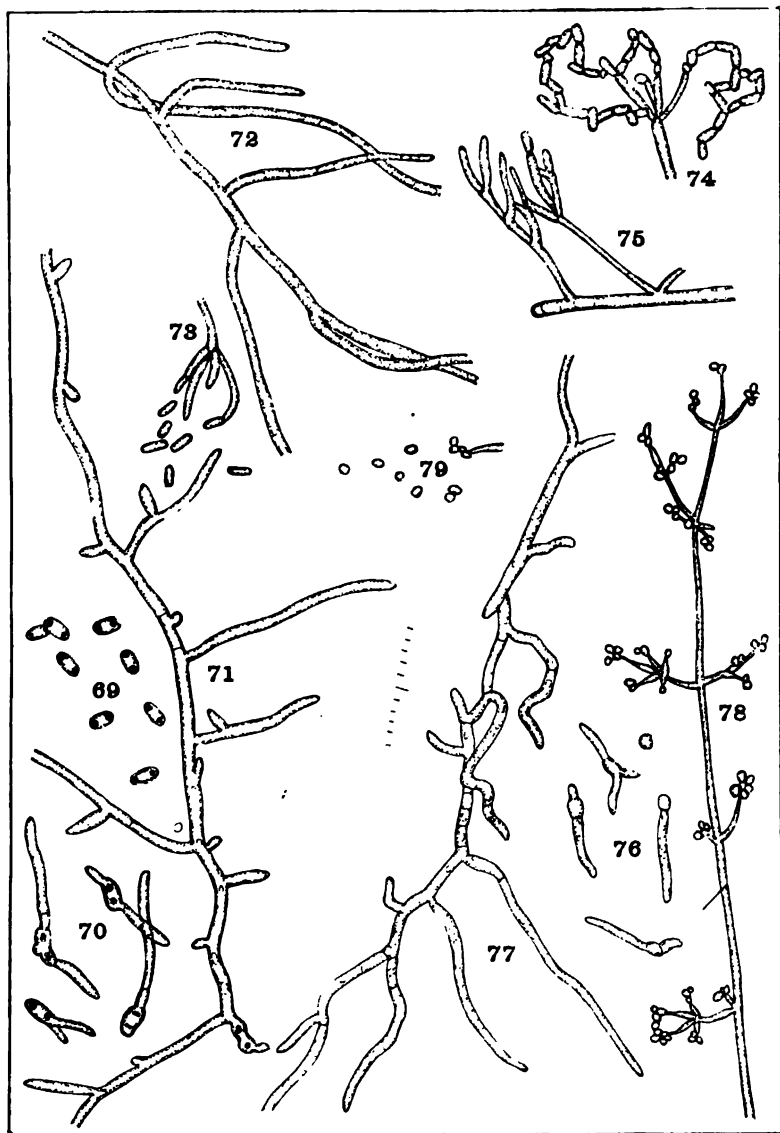


PLATE VII.—69-75, *Isaria anisopliae* var. *americana*; 76-79 *Isaria tenuipes*.

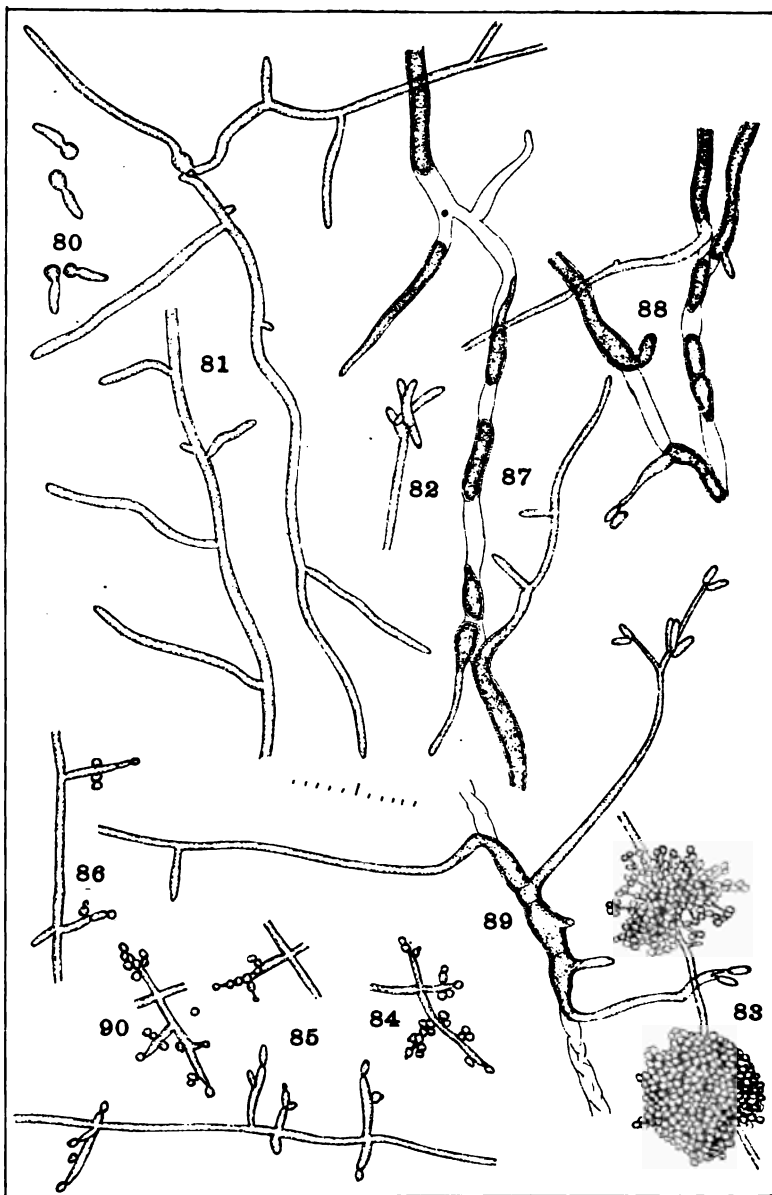


PLATE VIII.—80-90, *Sporotrichum globuliferum*. From carabid beetle.



PLATE IX.—91, *Isaria farinosa*; 92, *Cordyceps militaris*; 93, *Isaria farinosa*; 94, *Sporotrichum globuliferum* (*Isaria* sp?).

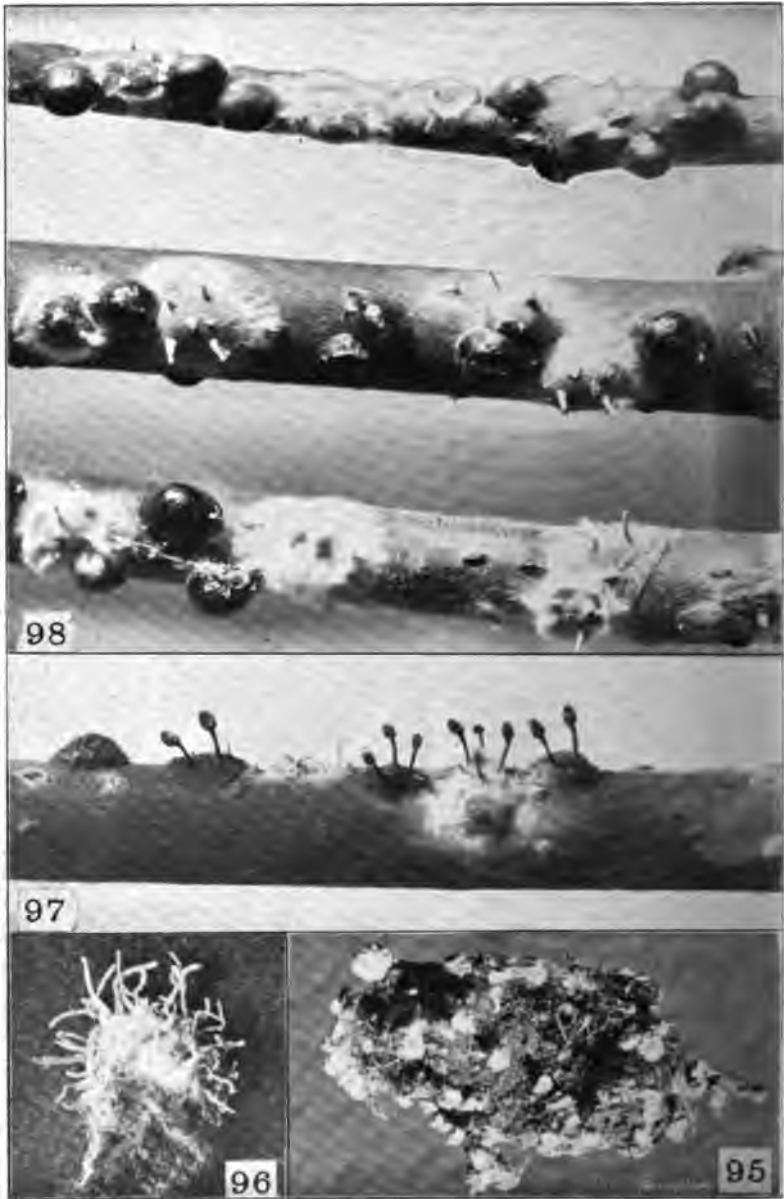


PLATE X.—95, *Cordyceps melolonthæ?* conidial stage; 96, *Isaria arachnophila*;
97, 98, *Cordyceps clavulata*.



PLATE XI.—99, 100, *Isaria leniupes*; 101, *Isaria vexans*.

N 7
C 8 eb



Bulletin 98.

Cornell University Agricultural Experiment Station.

HORTICULTURAL DIVISION.

CHERRIES.



Louis Philippe. Page 389.

By L. H. Bailey and G. H. Powell.

PUBLISHED BY THE UNIVERSITY.

ITHACA, N. Y.

1895.

ORGANIZATION.

BOARD OF CONTROL:

THE TRUSTEES OF THE UNIVERSITY.

STATION COUNCIL.

President, JACOB GOULD SCHURMAN.

Hon. A. D. WHITE,	-	-	-	-	Trustee of the University.
Professor I. P. ROBERTS,	-	-	-	-	President State Agricultural Society.
Professor I. P. ROBERTS,	-	-	-	-	Agriculture.
Professor G. C. CALDWELL,	-	-	-	-	Chemistry.
Professor JAMES LAW,	-	-	-	-	Veterinary Science.
Professor A. N. PRENTISS,	-	-	-	-	Botany.
Professor J. H. COMSTOCK,	-	-	-	-	Entomology.
Professor L. H. BAILEY,	-	-	-	-	Horticulture.
Professor H. H. WING,	-	-	-	-	Dairy Husbandry.
Professor G. F. ATKINSON,	-	-	-	-	Cryptogamic Botany.

OFFICERS OF THE STATION.

I. P. ROBERTS,	-	-	-	-	-	Director.
E. L. WILLIAMS,	-	-	-	-	-	Treasurer.
H. W. SMITH,	-	-	-	-	-	Clerk.

ASSISTANTS.

M. V. SLINGERLAND,	-	-	-	-	-	Entomology.
GEO. C. WATSON,	-	-	-	-	-	Agriculture.
G. W. CAVANAUGH,	-	-	-	-	-	Chemistry.
E. G. LODEMAN,	-	-	-	-	-	Horticulture.
MICHAEL BARKER,	-	-	-	-	-	Horticulture.

Office of the Director, 20 Morrill Hall.

Those desiring this Bulletin sent to friends will please send us the names of the parties.

BULLETINS OF 1895.

84. The Recent Apple Failures in western New York.

85. Whey Butter.

86. Spraying of Orchards.

87. The Dwarf Lima Beans.

88. Early Lamb Raising.

89. Feeding Pigs.

90. The China Asters.

91. Recent Chrysanthemums.

92. Feeding Fat to Cows.

93. The Cigar-Case-Bearer.

94. Damping Off.

95. Winter Muskmelons.

96. Forcing-House Miscellanies.

97. Entomogenous Fungi.

On account of the technical nature of Bulletin 97, only a limited edition was printed for the use of Experiment Stations and exchanges.

98. Cherries.

CORNELL UNIVERSITY, ITHACA, N. Y., }
July 10, 1895. }

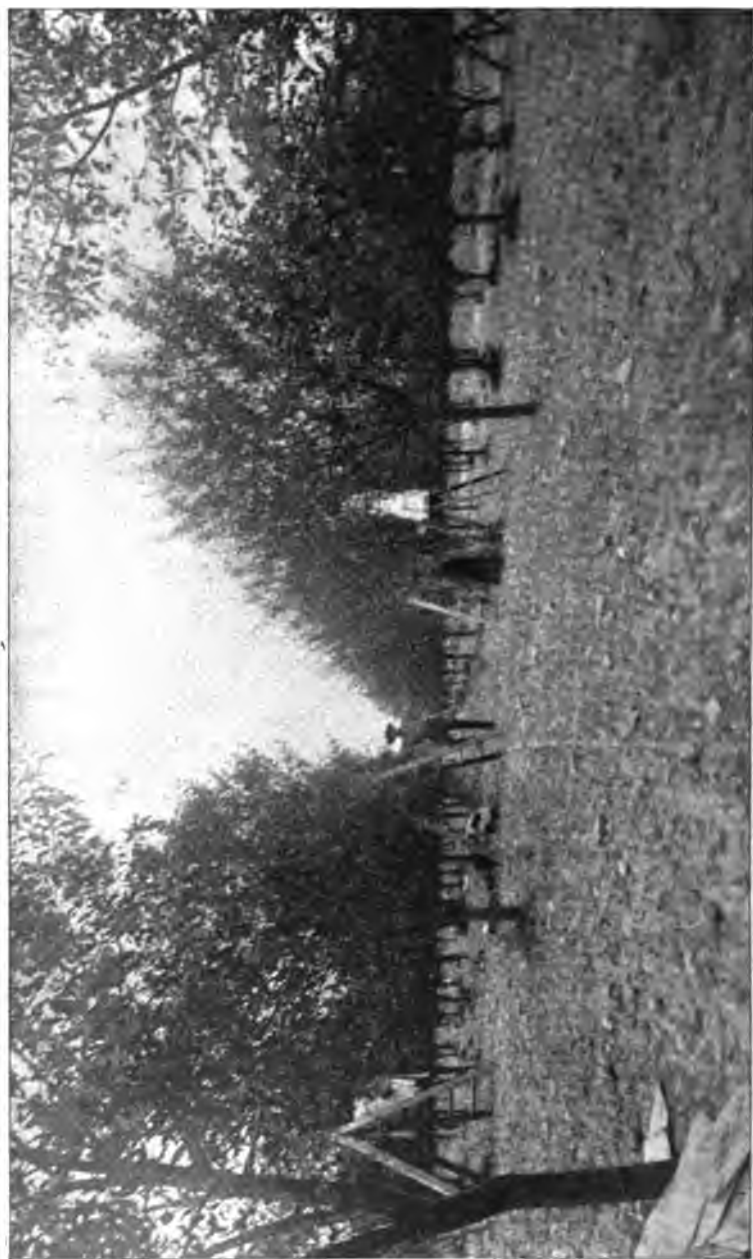
THE HONORABLE COMMISSIONER OF AGRICULTURE, ALBANY.

Sir:—The following account of cherry growing, written with particular reference to western New York conditions, is submitted for publication under Chapter 230, of the Laws of 1895. The older cherry plantations of the state were seldom anything more than scattered settings along lanes and roadsides, and about farm buildings. Most of these old trees have now passed their prime. In very recent years a new interest in cherry growing has been awakened by the demand from canning factories, and it has no doubt been stimulated, also, by the abundant sale of California cherries throughout the east. Sweet cherries are yet scarcely planted in western New York in orchard blocks, although there is every reason to believe that there is profit in the fruit if planters are careful to inform themselves concerning it. Sour cherries, however, are now planted to an important extent, particularly about Geneva, and the acreage is bound to increase. The pack of canned sweet cherries is still larger than that of sour cherries in western New York, in average years. The scattered plantings make uncertain crops, and cannery cannot buy as confidently as they could if there were more continuous plantations. Consequently the pack varies much from year to year. A normal pack for the Fifth Judicial Department may be considered to be nearly 100 tons of sour cherries and 150 tons of sweet cherries.

The literature of the whole subject of cherry growing is so meagre and so unsatisfactory, that I have taken much pains to ascertain the best methods and varieties for western New York. The chapter upon sweet cherries is contributed chiefly by G. H. Powell, Fellow-elect in Horticulture in Cornell University, who, with his father, George T. Powell, has had much experience with sweet cherries, and who, during last summer and this, has been employed as a special agent under the Laws designed to extend horticultural knowledge in the Fifth Judicial Department of the State. The other chapters are contributed by myself.

A full account of the native dwarf cherries will be found in our Bulletin
70.
L. H. BAILEY.

All the pictures of cherries in this Bulletin are made from life (except fig. 79) and they show the fruits exactly natural size. To the untrained eye, however, pictures look smaller than the objects from which they are made.



77.—*Montmorency Cherries at 9 years. (7 years planted). C. K. Soon, Geneva.—Tilled, fertilized, pruned, and sprayed.*

CHERRIES.

I. CLASSIFICATION OF THE CHERRIES.

1. *The Horticultural Groups.*

Before proceeding to a discussion of the general subject in hand, it will be necessary to define the terms and classification which are used throughout this paper. The cherry is a perplexingly variable subject, and the classification of the different types is much confused. In this account, I have conceived the cultivated tree cherries to be derived from two ancestral species, the Sour Cherries (*Prunus Cerasus*), which are characterized by a diffuse and mostly low round-headed growth and a habit of suckering from the root, flowers in small clusters from lateral buds and generally preceding the leaves, the latter hard and stiff, light or grayish green and rather abruptly narrowed at the top into a point, the fruit roundish and always red, the flesh soft and sour; the Sweet Cherries (*Prunus Avium*), with tall-growing, erect habit and bark tending to peel off in birch-like rings, flowers flimsy, in dense clusters on lateral spurs and appearing with the leaves, the latter large and more or less limp and gradually taper-pointed, the fruit variously colored, spherical or heart-shape, the flesh either soft or hard and generally sweet.

The Sour Cherry class includes two general types :

1. *Amarelles*, with pale red fruits, which are generally flattened on the ends, and an uncolored juice. Here belong the Montmorency, Early Richmond, and their kin. (The term Amarelle, from the Latin for *bitter*, is used by the Germans for these light-colored and white-juiced cherries, and it is the best term which I know for adoption in America. In France, however, it appears to have a less definite application.—See *Leroy, Dictionnaire de Pomologie*, v. 163. If this term is not acceptable, then I should choose *Kentish*, to designate this group of cherries.)

2. *Morellos or Griottes*, with very dark red fruits, which generally vary from spherical to heart-shape, and a dark colored juice. Includes the various Morellos, Ostheim, Louis Phillippe, and the like. (The word Morello is from the Italian, meaning *blackish*. *Griotte* is a French word, and was originally applied to these fruits because of their dark red brown color.)

The Sweet Cherry group is represented in this country by four types:

1. *Mazzards* (*Merisier* of the French), small fruits of various shapes and colors, represented by miscellaneous and inferior seedlings of the Sweet Cherry species. Mazzard trees are common along roadsides and in the borders of woods, where the seeds are scattered by birds. Mazzard seedlings, imported from Europe, are much used as stocks by nurserymen.

2. *Hearts or Geans*, with a soft-fleshed heart-shape fruit, represented by the Governor Wood, Black Eagle, Black Tartarian and the like. (The word Gean—French *guigne*—is an old name for the cherry, ultimately probably of Greek origin).

3. *Bigarreaus*, hard-fleshed, or crackling cherries, mostly of light color and heart-shape, comprising Windsor, Napoleon, Yellow Spanish, and others. (The word Bigarreau is French, sometimes anglicized as *bigaroon*, and it is applied to these fruits probably because of their *mottled* or *streaked* appearance. The typical bigarreaus are light red upon the sunny side, and whitish or lemon-yellow on the reverse).

4. *Dukes* differ from the heart cherries chiefly in having an acid or subacid fruit. Here belong the May Duke, Reine Hortense, Belle de Choisy and a few other sorts. Horticulturists, and even botanists, persist in classing the Dukes with the true sour cherries, but there is nothing to warrant such association beyond the mere incidental sourness of the fruit. The habit of tree, characters of flowers, leaves, and even of the fruits, are clearly those of the sweet cherry type. Even the sourest of them are sweet as compared with the true sour cherries, and there is every gradation from the type of May Duke to the typical Hearts. (May Duke is a corruption of *Médoc*, a district in southern France, whence the variety is said to have come. In France, the leading Dukes are known under the name of *Royales*, Jeffrey's Duke being called *Royale*, and May Duke *Royale hâtive*.)

2. *The Botanical Classification.*

There are few plants of which the botanical nomenclature is more perplexingly and delightfully mixed than the cultivated cherries. They were already widely grown and immensely variable when the science of descriptive botany was born. Nearly

every botanist who has taken up the study of them has arrived at a new conclusion respecting the number of the original species from which they have come. The extreme opinions are represented on the one hand by Bentham (British Flora), who accepts but a single species, and on the other by M. J. Roemer (Synopsis Monographicae), who makes thirteen species. It is consoling to know that Bentham's estimate cannot be reduced, and it is certain that Roemer's species cannot be distinguished. The oldest De Candolle (Prodromus) refers the cherries to four species, but he made the usual mistake of classing the Dukes and Morellos together; and it is also true that some of his species are indistinguishable in the absence of fruit. If one desires to recognize the most permanent horticultural differences and if he wishes at the same time to be able to distinguish the species which he makes, he will accept the division into two species, as proposed by Linnæus. These are *P. Cerasus*, the sour cherry type, and *Prunus Avium*, the sweet cherry type. I believe that these represent true original sources of the garden cherries.

It would be unwise to attempt a complete synonymy of the cherries in this place, but the following arrangement will explain most of the perplexities with which the student will meet :

I. *PRUNUS CERASUS*, Linnæus, Sp. Pl. 474 (1753). SOUR CHERRY.

P. acida, Ehrhart, Beitr. v. 162.

Cerasus vulgaris, Miller, Gard. Dict. 8th ed. No. 1.

C. Caproniana, DC. Fl. Fr. iv. 482 (Excl. Dukes).

C. acida, Bechst. Forstb. 161.

C. austera, Roemer, Syn. Monogr. iii. 75, in part.

C. tridentina, Roemer, Syn. Monogr. iii. 76.

C. Rhexii, VanHoutte, Fl. Serr. 2d ser. vii. 159.

Of the nine forms which DeCandolle dignifies with Latin varietal names, two are important in the present discussion, viz. : Var. *Montmorencyana*, including the Amarelle types (and also, wrongly, the May Duke), and Var. *Griotta*, including the Morellos and Ostheim. Roemer refers the Amarells or white-juiced cherries to *Cerasus acida*, and the Morellos to *C. Caproniana*. His *C. austera* comprises various sour varieties and the Dukes.

II. PRUNUS AVIUM, Linnæus, Fl. Suec. 2d ed. 474. (1755)
SWEET CHERRY.

Prunus Avium itself is held to represent the mazzard type.

Cerasus Avium, Moench Meth. 672.

C. rubicunda, Bechst. Forstb. 160, 355.

C. pallida, Roemer, Syn. Monogr. iii. 69.

Var. JULIANA. HEART or GEAN CHERRIES.

Cerasus Juliana, DC. Fl. Fr. iv. 482.

C. Heaumiana, Roemer, Syn. Monogr. iii. 69.

Var. DURACINA. BIGARREAU CHERRIES.

Cerasus Duracina, DC. Fl. Fr. iv. 483.

C. Bigarella, Roemer, Syn. Monogr. iii. 69.

Var. REGALIS. DUKES.

Cerasus regalis (*præcox* and *communis*), Poiteau and Turpin, Traité des Arbres Fruitiers, 123.

II. SOUR CHERRIES IN WESTERN NEW YORK.

The growing of sour cherries in western New York is largely confined to two varieties, the Montmorency and English Morello, and it is not yet fully determined which of the two is the more profitable in the long run. The preference has generally been given to the English Morello, as it bears younger than the other, and its dark colored and very acid flesh have made it popular with the canning factories. Just now, however, the canners are calling for the Montmorency in preference, for, whilst not so sour as the other in the natural state, it "cooks sour," and the Morello is apt to develop a bitterish or acid taste in the cans. The Morello is also much subject to leaf-blight, whilst the Montmorency is almost free from it; and the Montmorency is a stronger and more upright grower. The present drift is decidedly towards the Montmorency. The two varieties complement each other, however, for the Montmorency is about gone by the time the other is fit to pick.

This Montmorency of western New York is seen natural size in Fig. 78, and an orchard of it, seven years from the planting, is shown in Fig. 77, at the beginning of this bulletin. It is a very light red, long-stemmed cherry, broad, and flattened on the ends,

the flesh nearly colorless and only moderately sour. The tree is an upright vase-like grower.

This variety is supposed to be the *Montmorency ordinaire* of the French, but Leroy, the leading contemporaneous French authority (*Dictionnaire de Pomologie*), knows only one variety under this name, which is sold by "some nurserymen," and it is the same as the variety

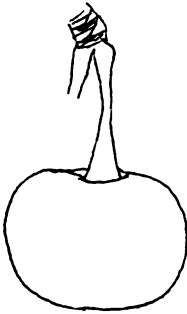
Hâtive (i. e., Early), which is very like the cherry known in this country as Early Richmond. The real *Montmorency* Leroy considers to be identical with the Early Richmond of English and American writers, although his description and figure of it make such association impossible. As nearly as I can determine, the *Montmorency* of western New York is the one



78.—*Montmorency*.

which Leroy figures as *Montmorency*, and not the *Montmorency ordinaire*. There is still a third French *Montmorency*, the *Montmorency à gros fruit* (i. e., the Large-fruited *Montmorency*), better known as Short-stemmed *Montmorency* (*Montmorency à courte queue*), and Gros-Gobet; in England and America it is often called Flemish Cherry or Flemish *Montmorency*. (See Downing,

480 ; Leroy, v. 365 ; Lauche, *Deutsche Pomologie*, Kirschen, 19.) This variety is characterized by a very short stem, which at once distinguishes it from other cherries. Leroy's diagram of the



79—*Large-fruited or Short-stemmed Montmorency.*
(After Leroy.)

fruit of this Large-fruited Montmorency is here reproduced (Fig. 79). I do not know that this variety now exists in this country. It was early imported, with other sorts, by Ellwanger & Barry. They grew it as *Montmorency à courte queue*, and applied the name *Montmorency Large-fruited* to another cherry, which W. C. Barry tells me was superior to the common Montmorency in quality, but which proved to be unproductive. So it happens that the Montmorency Large-fruited of western New York is not the French variety of that name. It should be remarked, in passing, that the standard and monumental work of Poiteau (*Pomologie Française*) con-

tains no such varieties or synonyms as *Montmorency ordinaire* and *Montmorency à gros fruit* (large-fruited), but Leroy, whom I have quoted, has recently (1877) made an elaborate attempt to untangle the synonymy.

Early Richmond (Fig. 80) is the only other Amarelle, or white-juiced cherry, which is grown to any extent in western New York, and this is not very valuable. Its flavor and quality are poor, the fruit is soft and small, and it is so early that it competes with the late strawberries. It is considerably used by canners, but the better cherries are bound to drive it out.

Amongst the Griottes, or red-juiced cherries, three have gained some notoriety in western New York,—the Ostheim, Louis Phillippe, and Morello.

The Ostheim is a very productive variety, ripening about a week after



80.—*Early Richmond.*

Early Richmond, but it is too small and too early to be valua-

ble for general cultivation here. As compared with Early Richmond, it is darker red, rounder and somewhat smaller, the stem longer, stouter and straighter, flesh and juice dark red and less acid. (Compare Figs. 80 and 81.) Hangs long on the tree.

Louis Phillippe (see title-page) is one of the best of all the sour cherries, and it would no doubt be generally grown were it not for the prev-

alent opinion that it is unproductive. C. W. Stuart, of Newark, who has had a long experience with this cherry, tells me that it is a profuse bearer when the tree has attained some age, and he



81.—*Ostheim.*

thinks that it might be more freely planted with profit. It seems to be particularly attractive to the curculio, and some growers regard this as the cause of its unproductiveness. The fruit is nearly spherical, about the size of Montmorency and rather sourer, very dark red in skin and flesh, of very best quality. Ripens with Montmorency. I do not know if the Louis Phillipe of western New York is properly named or if there are two varieties of the same name. Leroy makes the name a synonym of Reine Hortense, a very different fruit.

The Morello (Fig. 82), variously known as English, Large, Dutch and Ronald's Morello, is nearly two weeks later than Montmorency, a bushy and finally a drooping grower, with medium-sized, roundish or round-cordate fruits which become red-black when fully ripe. Flesh very dark, much sourer than

the Montmorency. In western New York the Morello harvest begins from the 8th to the middle of July.



82.—*English Morello.*

The cherry orchard.—A strong, loamy soil, and one which is retentive of moisture, is the most suitable for sour cherries. The fruit contains such a large amount of water that it is necessary to save the moisture of the soil to the greatest possible extent. Dry clay knolls produce cherries of less size and of inferior quality than the moister depressions between them. Very early and thorough cultivation is essential to this conservation of moisture, and the tillage should be continued at frequent intervals until the fruit is about ripe. In order to be able to cultivate the soil at the earliest moment in the spring, the land should be either naturally or artificially well drained. The crop of even the Morellos is off the trees in July, so that there is abundant opportunity to sow a catch crop on the orchard for a winter cover, if the manager so desires. A variety of plants may be used for this cover. The best is probably crimson clover, particularly if the orchard needs more nitrogen or growth; and if American grown seed is sown by the middle of August in a well prepared soil, the cover will probably pass the winter safely. Other plants which may be used for cover are rye, winter wheat, vetch, field pea, sowed corn, millet and buckwheat. Of these, only the two first will

live through the winter and grow in the spring. In using cover crops which survive the winter, it is very important that they be turned under *just as soon as the ground is dry enough in spring*. As soon as the plant begins to grow it evaporates moisture and dries out the soil; and it is more important, as a rule, to save this moisture than it is to secure the extra herbage which would result from delay. This is especially true with the sour cherry, which matures its product so early in the season, and which profits so much by a liberal and constant supply of soil moisture. Plowing can also be begun earlier on land which has a sowed crop upon it, because of the drying action of the crop. The fertilizers which give best results with other orchard fruits, may be expected to yield equally good returns with the cherry. (See Bulletin 72.)

It is an almost universal fault to plant cherry trees too close together. The Montmorency should not be planted closer than 18 feet each way, in orchard blocks, although it is often set as close as twelve feet. The English Morello is a more bushy grower and may, perhaps, be set as close as 16 feet with success; but I believe that even this variety should stand 18 feet apart. The sour cherry orchards in western New York are yet so young, that the evil effects of close planting have not yet been made apparent. I find, however, that nearly every shrewd orchardist who has had experience with these fruits, is convinced that the general planting is too close.

Cherries are usually set when two years old from the bud. The sour varieties are propagated both upon Mazzard and Mahaleb stocks, chiefly the latter, but the comparative merits of the two are not determined. The tops are started about three or four feet high, and the subsequent pruning is very like that given the plum. If the young trees make a very strong growth and tend to become top-heavy, heading-in may be practiced; but this operation is not considered to be necessary after the trees begin to bear. Cherry trees require less attention to pruning than apple trees and peach trees do. The orchard shown in Fig. 77 may be taken as a model, except that the trees are too close together.

The English Morello will bear a fair crop the third year after setting, if two-year trees are planted. The Montmorency is a

year or two later in coming into bearing. The Montmorency, partly because of its larger growth, produces much more fruit than the other, when it arrives at full bearing. Individual trees of Montmorency at six years and upwards may bear from 30 to 75 pounds of fruit; but Mr. Scoon considers 8 to 10 tons of marketable fruit to be an excellent crop on an orchard of 800 Montmorencys 8 years planted—that is, an average of 20 to 25 pounds to the tree. The Morellos, because of their dark color, usually sell better than the Montmorency in the open market, but the reverse is now generally true if the crop is sold to canning factories. This year, the factories have paid five and six cents a pound for Montmorencys. It is easy to figure the proceeds of an acre. At 18 x 18 ft., an acre will comprise about 130 trees. If, at 8 years, they yield 20 pounds each, the crop would amount to 2,600 pounds, which, at 5 cents, means \$130. This is a conservative estimate. Benjamin Kean, Seneca, has 200 Montmorency trees 6 years set. He has had three crops, one of 1,400 pounds, one of 3,000 pounds, and one 3,100 pounds. He sold his entire crop this year for 5 cents, making a gross income of \$155. His trees are set 10 x 12 ft., which allows about 360 to the acre. In other words, a crop which sold for over one hundred and fifty dollars was taken from less than two-thirds of an acre. The soil, in this case, seems to be unusually well adapted to this cherry and the crops have, therefore, been excellent; but, on the other hand, part of the crop was destroyed this year by the curculio. C. H. Perkins, Newark, has 35 trees, 8 and 12 years old, all Montmorency. "They bear," he writes, "from 2,000 to 3,500 lbs. of cherries per year and the average price that we get for them is 6 cents. They net us from \$100 to \$175 a year. They are the most regular and sure cropper of any fruit we have ever tried to grow, and the fruit always finds a ready market at a good price." The Maxwell orchard at Geneva, yielded over 11 tons, Montmorency, this year, from 800 trees.

My reader will now want to order enough cherry trees to plant his farm. But he should go slow. It may be laid down as a principle that no crop will bring uniformly great rewards over a series of years. These results with sour cherries are obtained only when all the conditions are present, such as the proper soil, excellent care and fertilizing, ability to secure pickers, and access

to good markets. One could probably not rely upon the open market for the disposal of a very large planting of sour cherries. He should have access to one or more canning factories. It is a fact that more than half of all the orchards, of whatever kind, which are conceived in expectation and planted with enthusiasm, turn out to be profitless. The fault lies somewhere under the owner's hat. Persons who fail to grow other fruits with profit, may also expect to fail with cherries. Yet I know of no fruit which, upon the testimony of both producers and consumers, offers a greater reward than sour cherries. The public seems to have acquired a taste for the canned product, and there is every indication that this demand will increase.

The labor of picking cherries, which is a bugbear to so many who would like to plant the fruit, is really no more onerous than the picking of raspberries or currants. If one lives where pickers cannot be had with certainty, and in sufficient numbers, cherries should not be planted. Parties who hire pickers by the piece, pay three-fourth cent or a cent a pound. The trees must be gone over twice, at intervals, and generally three times, and it is important that all those fruits which are ripe, and no others, should be secured at each gathering. It is more difficult to see that this is done on cherry trees than on berry bushes, and for this reason some growers prefer to hire pickers by the day. When picking for canners, the fruit may be allowed to become much riper than when it is to be sold in the open market, and it is not necessary to exercise so much care to preserve the stems upon the fruits. The English Morello drops easily when ripe, and growers sometimes shake off the cherries—if designed for canning—onto sheets or, if the trees are small, into a Johnson curculio catcher. If cherries are carefully hand-picked for the general market, the stems being left on, a pound of fruit measures about a quart and a quarter, but as the fruit is generally picked for canning, a pound is about a quart.

Insects and diseases are not serious upon the sour cherries. The curculio does not often attack the midseason and late varieties—such as Montmorency and Morello—seriously, particularly if the number of trees is somewhat large. In occasional years, however, this insect becomes a scourge. The grower must watch his fruits closely after the blossoms fall, and if the curculio injuries

become alarming, he must catch the insects by jarring them onto sheets. There are those who declare that they attract the curculio away from the cherries by planting plum trees in the cherry orchard, but I greatly doubt the efficiency of this procedure. A complete account of the curculio may be expected in a forthcoming bulletin.

The leaf-blight or shot-hole fungus (*Cylindrosporium Padi*, or *Septoria cerasina*, the same which attacks the plum), is often a serious enemy, particularly upon the English Morello. The leaves begin to assume a spotted character, generally before the fruit is picked, they soon turn yellow, and they fall prematurely. Thorough spraying with Bordeaux mixture is as efficient in holding the leaves on the cherry as it is on the plum. The trees should generally be sprayed twice between the falling of the blossoms and the coloring of the fruit. If the cherries are more than half grown when the last spray is applied, the ammoniacal carbonate of copper may be used in place of the Bordeaux, to avoid discoloring the fruit. But it is doubtful if the last spray should be delayed until this time. It may be necessary to spray once after the fruit is off.

A thin grayish powdery mildew (*Podosphaera Oxyacanthæ*) frequently attacks the fruits and leaves of the sour cherries, particularly when the trees are overshadowed by larger trees or buildings. I have never known it to be serious upon the fruit, as it appears about the time the fruit is ripening, covering the cherries with a very delicate coat, like dust. In this case a late spraying with ammoniacal carbonate of copper would certainly be effective. The only emphatic injury which I have ever seen from this fungus upon cherries occurs after the fruit is off, when it may attack the ends of the shoots, checking the growth. At this time, if the injury threatens to be serious, Bordeaux mixture may be used.

The black-knot, which seriously invades sour cherry trees, is fully treated in our Bulletin 81.

III. THE SWEET CHERRY INDUSTRY.

Unlike most other fruits, the sweet cherry has never attained a prominent position as a horticultural industry in western New York. There is not a single orchard of it west of Albany, so far as I know. Along the Hudson, however, there are three or four orchards. It is from the few trees scattered on every farm throughout the state, that the cherry crop is mostly harvested. It should not be concluded, however, that the smallness of the industry follows from a lack of appreciation on the part of New York people of this most luscious fruit. It is due to the fact that the cherry is one of the most difficult crops to handle and market successfully, because of its exceedingly delicate character, and its susceptibility to the fungus, which causes the brown rot. This fungus spreads so rapidly on the ripening fruit, that a promising crop to-day may be half rotted to-morrow. The comparative ease of handling and marketing a grape, an apple or a pear crop, have made those fruits universally popular, while the cherry has lain in obscurity.

The cherry is one of the most popular dooryard fruits and its hardiness, its vigorous spreading or ascending branches, its upright form which often attains the height of 40 to 50 feet, and its luxuriant, soft drooping foliage make it a most desirable tree for ornamental and fruit bearing purposes. Amongst the strongest recommendations of the cherry are its hardiness and the fact that it bears annually when properly treated. The trees begin to grow very early in the season and the fruit of most varieties is harvested by July 1, thus leaving the tree sufficient time and energy to perfect the fruit buds for the coming year, and if the wood ripens during the fall the mercury can fall to 20° below zero, without injury to the coming crop. There seems to be a general inquiry among fruit growers and farmers concerning the care of cherry orchards, the most desirable varieties, the diseases, and methods of handling and marketing a crop. As these matters are more fully understood, the cherry industry may be expected to reach a prominent position among the other horticultural industries.

Soil and location.—The cherry tree is a gross feeder and grows with surprising rapidity, the limbs of young trees sometimes increasing from four to six feet in one season. This characteristic of the cherry must not be lost sight of in selecting a site for the

cherry orchard, for when too rapid growth takes place the trunks and large limbs split open, the sap exudes abundantly, little or no fruit is borne and the life of the tree is short. The cherry will grow in a variety of soils, even where other fruit trees will not thrive, but the ideal soil is a naturally dry, warm, mellow, deep gravelly or sandy loam, of good quality, containing sufficient humus to retain moisture and give lightness, but not enough to make the soil damp and heavy. If the soil is not naturally dry it must be well drained, for dryness is essential to success with the vigorous growing sweet cherries. While more orchards are unproductive from a lack of plant food than from an excess, it is well to remember that the vigorous growing habit of the cherry lays it open to severe injury and unfruitfulness if the soil is too rich.

The ideal situation for the orchard is a high altitude which insures good atmospheric as well as land drainage and lessens the dangers from late frosts in the spring and from the rot. The cherry is an early bloomer, and it should be placed where the cold air at night will settle away from it, as injuries from spring frost frequently occur.

Distance of trees.—Since the cherry attains a large size, the limbs spreading twenty feet or more and the roots reaching a long distance, it must be given plenty of room, and I am convinced that thirty feet each way is the proper distance to set sweet cherries. I have seen trees twenty-two feet apart with their main branches interlacing, and the trees were allowed to assume a pyramidal form instead of a spreading habit. At thirty feet each way an acre contains fifty trees.

Pruning.—The cherry orchard will require little pruning after the first two or three years, and before that time the tree can be made to assume any desired form. I believe, however, that in general the pruning should be such as to give the tree a low spreading head with a trunk about 4 feet high and with the top built out on 3 to 5 main arms. We have pursued this method on the Windsor and other varieties and the trees, instead of growing in the usual spire-shape, assume an apple-tree form. After the first two or three years no pruning is needed, except to remove dead branches and to keep superfluous branches from intercrossing.

The advantages gained from this form of tree are of great impor-

tance. First the body of the cherry tree is less likely to be injured from the hot sun, which causes it, especially on the side of the prevailing wind, to crack and split, exude sap and finally to die. The low spreading head shades the trunk and large branches and obviates this difficulty to a great extent. In western New York this trouble is not so serious as it is on the black lands farther west. A second advantage, of equal or greater importance, lies in the fact that, if allowed to grow upright, the limbs reach the height of 30 to 40 feet in twenty-five years, making it very difficult to gather the fruit and to spray the trees. The bearing branches are always found towards the extremities of the limbs, and the time which men lose in going up and down long ladders is of no small account to the fruit grower.

Cultivation.—A young cherry orchard should be given clean cultivation. Small fruits, like currants, raspberries or gooseberries or any others that require frequent cultivation, may be set between the rows for 8 or 10 years, but the bushes should be removed in the tree rows and opposite the trees at the end of the third year. No crop that does not require cultivation should ever be raised in the orchard. In general, the methods described in Bulletin 72 upon "The Cultivation of Orchards" should be followed.

At about five years old the trees begin to bear fruit of consequence, and at ten years they give paying crops. As the orchard comes into bearing, the management of the soil will differ according to its nature, and the trees themselves should be the indicators of their treatment. Though there have been no experiments in the treatment of bearing cherry orchards, I believe that clean culture should generally be stopped by June 15, or July 1, so as to check growth and give the wood sufficient time to ripen. The advantages of this treatment are also pointed out in the Bulletin mentioned above. Whenever the growth becomes too luxuriant, it can be checked by seeding a year with clover.

A certain cherry orchard has stood in sod for fifteen years in an ideal soil and situation. The trees are making little growth and are filled with dead limbs, and while there was a heavy crop of cherries this year, the size was small, quality poor and one-half were rotting on the trees. In striking contrast was a neighboring orchard which had been plowed lightly in the early spring and had had a harrow run over it once a week up to the middle of

June, and although there had been a severe drought, the trees had made a good growth and were loaded with luscious fruit of large size. The latter orchardist believes that he can produce as large cherries as the Californians can, by high cultivation and the conservation of moisture the early part of the season. As a means of holding moisture, he is putting humus in the soil by cover crops and expects to check too luxuriant growth by seeding the orchard whenever it becomes necessary. While dryness is a universal maxim for the cherry, it is advantageous to conserve moisture during the development of the fruit, and the example furnished by this orchard convinces me that the fruit can be increased one-half in size by thorough light cultivation up to the middle of June.

Fertilizers.—The cherry probably requires as little fertilizer as any fruit grown. An occasional crop of crimson clover turned in will generally furnish sufficient nitrogen and improve the soil in other ways. Potash can be furnished in wood ashes or in a high grade muriate of potash, using 250 lbs. per acre of a 50 per cent. muriate. This should be applied in the spring and harrowed in. Phosphoric acid may be applied in the same proportions in the form of bone compounds or in South Carolina or Florida Rock. In good soil, it is seldom that the cherry orchard needs heavy fertilizing if clean culture is practiced; the close observer can tell when to apply plant food by the action of the trees themselves.

Limits to the profitable age.—The cherry will live to a great age and bear fruit, there being records of such trees over a hundred years old. As the cherry industry is so small, and no great number of trees have been treated as an orchard for a long time, it is difficult to say just how long an orchard will continue to be profitable. This will depend largely on the variety. In general, I should say that thirty years is the limit to the most profitable age. After that time the trees become so large that the expense of picking the fruit and caring for the trees increases rapidly.

Handling the crop.—Before one goes into the sweet cherry industry as a business, it should be clearly understood that the cherry is a delicate fruit and more susceptible to injury from handling and from changes in the weather than the strawberry, and the industry should not be taken up unless plenty of good pickers can be obtained on short notice and unless desirable markets are within reach in 8 to 10 hours after the fruit is picked.

It is one thing to raise a crop of fruit, but an entirely different thing to handle and market it successfully. These remarks apply with particular emphasis to the sweet cherry, because the crop has to be sold immediately when ripe and the delay of a day may mean the loss of the entire crop, as the commission men "slaughter" the sales when the fruit begins to go down. It is strongly recommended that the markets be thoroughly looked up and studied before one goes into the cherry business.

The first essential in handling a crop of cherries is to have the fruit picked with great care, the stem being left on each cherry, and only the stem touched with the fingers. The most desirable method of picking is in 8 lb. baskets, as in a larger package the bottom fruits are pressed too heavily. I saw delicate Tartarian and Governor Wood picked in half bushel baskets this summer and then turned into 12 lb. baskets for shipping, and the grower wondered why his cherries got into market, which was only three hours away, in such poor condition! The handling of cherries and walnuts should never be confused! Unless pickers are closely watched, a good many fruit spurs will be broken off, especially if the fruit has a tendency to grow in clusters. This should be carefully watched, as it destroys the fruit buds for the coming year. The fruit should be picked a few days before ripe. Pickers earn \$1.50 to \$2.00 per day in a good crop, at one cent per pound.

The manner in which fruit is placed on the market, especially all delicate fruits, has as much to do with selling it as the quality of fruit itself. The demands of the market should always determine the method of packing. This can be learned by correspondence with reliable commission men, who would often obtain better prices for cherries and other fruit, if their advice were asked and followed. For the general market, there is probably no better package for the cherry than the eight-pound climax grape basket, but for the finer classes of cherries and the retail trade (which should always be worked up for the finest cherries) a smaller package is more desirable. There are several packages which hold from six to twenty boxes or baskets, the whole package weighing not more than 40 lbs. when full, which are desirable. A package heavier than 40 lbs. will be roughly handled by transportation companies. In the small packages the fruit should be made very attractive. All stemless or bruised cherries should be thrown

out, and the top layer of fruit faced in rows with the stems hidden. This work can be done rapidly by girls or women, who lay the cherries on the bottom of the box in rows, fruit side down, then fill the box, nail and turn it over, mark the faced side and put it in the crate. If baskets are used in the package instead of boxes, the top of each basket should be faced. The extra cost of facing the fruit pays in the ready sale which it brings.

I will recite a bit of our own experience of the present year: Black Tartarian and Napoleon Bigarreau cherries were packed in two styles of packages, the fruit being handsomely faced in both cases. A spring crate or case holding six boxes of cherries each containing 6 lbs. (36 lbs.), sold for \$1.50 by one Boston firm and \$1.75 by another and \$1.75 by a New York firm, or 4½ cts. per lb. Another case holding twenty two-pound baskets (40 lbs.), sold by the Boston firm for \$3.75 and \$4.00 and by the New York firm for \$4.00, or 9½ cts per lb. Both packages cost the same. In another instance, Black Tartarians were shipped in five-pound baskets and sold for 30 cts., or 6 cts. per lb., while those shipped in eight-pound baskets brought 65 cts. and 70 cts., or 8½ cts. per lb.

All these remarks apply to fruit sold in the general market; but there is a great demand for sweet cherries from the canning factories, for which the fruit, while carefully harvested, is less laboriously packed.

Profits.—The profits from the cherry industry depend mainly on the efforts of the grower in producing first-class fruit and in placing it on the market somewhat after the directions given in the previous topic. In 1888, an acre of cherry trees, 18 years old, including Black Tartarian, Black Eagle, Napoleon Bigarreau, Elton, Yellow Spanish and Downer's Late Red, netted \$380, while an acre of rye netted \$8.

The following sample figures are taken from sales from the orchard this season, trees 25 years old:

Five trees of Robert's Red Heart averaged 280 lbs. per tree; the fruit sold for 9 cents. per lb. bringing \$25.20

The expenses were:	Picking	.	.	\$2.80	
	Packages	.	.	1.40	
	Packing	.	.	1.25	
	Express	.	.	2.80	
	Commission	.	.	2.52	\$10.77
	Net profit per tree	.	.		\$14.43

One tree of Robert's Red Heart yielded 416 lbs., which sold to retail dealers at 10 cts. per lb. at the express office, \$41.60

Expenses :	Picking	\$4.16	
	Packages	1.56	
	Picking	1.75	\$ 7.47

Net profit		\$34.13
------------	--	---------

One acre of Windsors containing 70 trees 8 years old, yielded 84 lbs. per tree—5,880 lbs., which sold at 10 cts. per lb., \$588.00

Expenses :	Picking	\$58.80	
	Assorting and Packing	20.00	
	Packages	30.00	
	Express and Commission	70.00	
	Cultivation (plowed once, and harrowed six times)	3.50	
	Fertilizers (300 lbs. Potash, 100 lbs. bone, 15 lbs. crimson clover seed)	4.25	
	Interest on land at \$1.50 per acre	9.00	\$195.55

Net profit		\$382.45
------------	--	----------

All these figures refer to sales in the open market. There is a good demand for sweet cherries for canning factories. The canners generally prefer the "white cherries,"—those with a white juice and rather light-colored skin. The crop of sweet canning cherries in western New York appears to be growing smaller, and the California product has driven out much of the home-made goods. One of the best informed canners in the western part of the state, writes as follows concerning the sweet cherry pack. "Up to six or seven years ago, we handled from fifty to one hundred tons annually. The cherry crop appears to be growing smaller each year, and to be deteriorating very much in quality. Our output on cherries used to be composed largely of the white varieties, and we used to put up fine grades that were esteemed very highly in New York and the eastern markets. Some years ago, California began to can cherries and subsequently put them on the eastern markets in competition with the finer grades of eastern cherries. The result was that the California product drove the eastern canned cherries almost entirely out of the market, except in some of the cheaper grades. The California cherry is much finer in appearance, is larger, freer from worms and imperfections, and also possesses a very fine flavor."

The canners tell us, in general, that when they can get good fruit, they have no trouble in making a saleable product. It is evident that good fruit cannot be obtained, year by year, unless the trees are planted in such way that they can be well cared for. The price paid for sweet cherries by canning factories, runs from three to five cents per pound.

Varieties.—Among the most prominent Hearts are Belle d'Orleans, Knight's Early Black, Black Eagle, Black Tartarian, Kirtland's Mary, Coe's Transparent, Downer's Late Red, Elton and Governor Wood. The most prominent Bigarreaus are the Yellow Spanish, Mezel, Napoleon, Rockport, Tradescant's Black Heart (Elkhorn) and Windsor.



83.—*Governor Wood.*

For general market purposes, the firm-fleshed varieties of a black or red color are preferable, as they ship better, do not show finger marks from handling, and are not so susceptible to the rot. From the Hearts, Knight's Early Black, the Black Tartarian, Black Eagle and Downer's Late Red might be added.

Governor Wood is probably the cherry most common to western New York and is shown in Fig. 83. The tree is a vigorous grower and forms a regular, round head. The fruit is light red or light yellow with a red cheek, short-cordate, soft, sweet and good. Peduncle of medium length, inserted in a broad cavity; flesh nearly colorless. This variety is an excellent one for home use but cannot be recommended for market, because of its tender, light flesh, and its great susceptibility to rot. Ripens about the middle of June.

Elton.—The Elton is another cherry commonly set. Tree vigorous, upright, leaves with darkened footstalks. Fruit heart-pointed, distinct in shape, large, yellow, much overlaid with cherry red. Flesh firm, becoming soft, white, juicy when ripe, and luscious. Heavy, regular bearer, but not a desirable market

variety, because of its light color, tender flesh and susceptibility to the rot. Fig. 84.

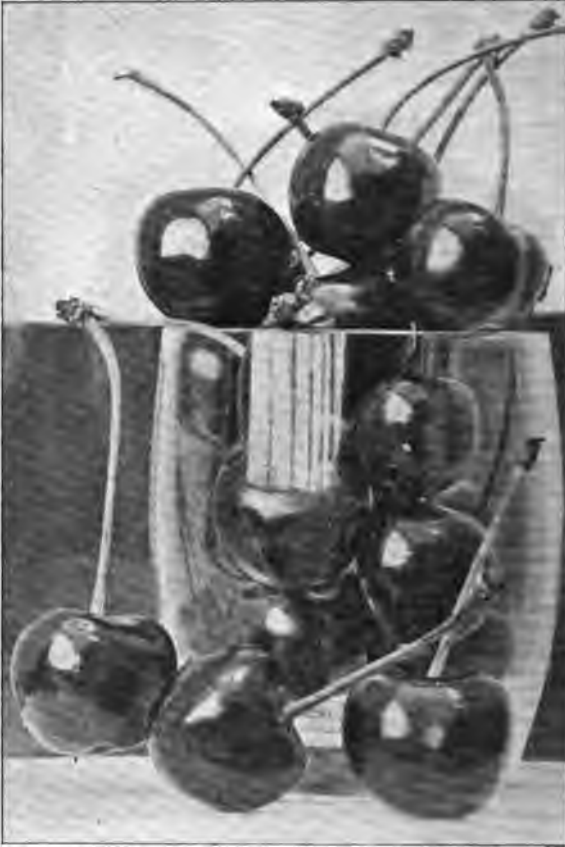


84.—*Elton*.

Black Tartarian.—Tree vigorous and rapid grower, erect when young, becoming spreading when older, the large limbs losing side branches giving the lower interior a bare appearance. Fruit attached by threes, short-cordate, not pointed. Flesh dark purple, soft, but firmish; deep, dark red or black. Juice very sweet and abundant. Stone small. Peduncle $1\frac{1}{2}$ in. long, set in a flattened, shallow cavity. Regular and heavy bearer, quality *excellent*. Ripe the middle of June. The Tartarian is the best black heart for market and family purposes. It does not rot as badly as the light hearts, and though not as firm as desirable, its high quality, regularity in bearing, and dark color recommend it strongly. Fig. 85.

Black Eagle.—Tree a rapid grower, erect with roundish head, top dense, large limbs not bare as in Tartarian. Fruit large, borne in pairs and threes, in thick clusters on the spurs, obtuse or pointed. Color same as Tartarian and slightly more acid. Flesh same color. Quality excellent. Moderate bearer. Does not rot as badly as the light hearts. One of the best dark hearts for market and family use. Ripe just after the Tartarian. Fig. 86.

Downer's Late Red.—Free, rapid grower, head upright and roundish. Fruit medium size, roundish, heart-shape. Skin of



a delicate red, mottled with amber where shaded, very tender, melting, luscious. Fruit hangs for considerable time on tree. A heavy, regular bearer. Does not rot badly. Ripe about July 8. A good, late, tender variety.

There are many other heart cherries that might be described, but it is the intention of this paper to give only the leading varieties; some may have been omitted and their descriptions can be

85.—*Black Tartarian*.

found in the leading horticultural books. The same remarks may also be applied to the firm-fleshed kinds, only the leading varieties of which will be given.

Napoleon.—Tree medium size, erect with roundish head. Fruit borne generally in twos; very large, oblong-cordate; light lemon yellow with red cheek in the sun. Flesh *very* hard,

brittle, colorless, reddish at stone. Stem medium length, stout, in a moderately deep, even cavity. Good. Excellent bearer. Ripe about June 20. Rots badly when ripe and splits if left too long. The Napoleon Bigarreau is probably the most desirable



86.—*Black Eagle*.

light colored cherry for market purposes. Its hard flesh and large size make it a good shipper and an attractive fruit when placed in small packages. Although it rots badly, if picked as soon as well colored and before ripe this difficulty will be largely obviated. It must be watched closely in humid weather and when the first signs of rotting appear, the crop must be picked or it will be lost, Fig. 87.

Robert's Red Heart.—The following description applies to a variety of that name grown in eastern New York. The description given in Downing is not clear enough to positively establish its identity, but the history of the plantings seems to establish its name beyond a doubt. Tree erect, not spreading, roundish, vigorous grower, dense. Fruit short-cordate, as large and as fine as the Napoleon, in large clusters; bright dark red, with an under mottling. Peduncle long, set in a moderately deep, broad depression. Flesh pinkish; subacid. Juice nearly colorless. Hand-

some. Quality fair. Does not rot as badly as the Napoleon. *Very* heavy regular bearer. Ripens with the Napoleon. The fruit should be faced in fancy packages. One of the best firm-fleshed cherries. Fig. 88.



87.—*Napoleon*.

Mezel (Bigarreau de Mezel).—Tree a vigorous upright grower, leaves large. Fruit very large, obtuse, heart-shape, flattened on both sides, uneven. Skin dark red to black. Firm, but heart-like, juicy, meaty, very sweet and rich. Stem long, slender and tortuous. Handsome and excellent. Said to be a prolific bearer, though I have seen only a few trees in fruit. Ripe about June 20.

Windsor.—Tree upright, vigorous and rapid grower, leaves large. Fruit large, roundish oblong, very firm, juicy, mottled red; flesh pinkish, sometimes streaked. Peduncle, medium length, stout, set in a slight broad depression. Quality good. Heavy bearer. Ripe about July 4. Attacked freely by curculio. The most desirable late cherry either in the firm or tender-fleshed varieties. It hangs a long time and does not rot badly. Fig. 89.

The Dukes are chiefly represented in New York by May Duke, Reine Hortense, and Belle de Choisy. The May Duke (Fig. 90)

is a large very dark red cherry, short-cordate, soft, the flesh colored and subacid, of excellent quality. One of the best family cherries, but little grown for market because of its softness. A peculiarity of the May Duke is its habit of ripening unevenly. It is not infrequent that one branch or one part of the tree matures its fruit whilst the remainder of the crop is still green. Sometimes the two sides of the same fruit mature at different times. . Reine Hortense is an oblong-cordate, light yellow cherry overlaid with amber and splashes of light red. Flesh nearly white, very soft, sub-acid, of medium to good quality. Rots badly. Belle de Choisy is one of the best of dessert cherries, but is too unproduc-



88.—*Robert's Red Heart*

tive and too soft for market purposes. It ripens just after the May Duke. Fruit roundish, the skin thin and amber with mottled red.

Varieties subject to rot.—In general, it may be said that the tender-fleshed varieties of cherries rot worse than those having firmer flesh and among those which are the most susceptible to it are Governor Wood, Elton, Coe's Transparent, Belle d' Orleans, Belle Magnifique, Rockport Bigarreau, Cleveland Bigarreau, and Napoleon Bigarreau. Among those that are least susceptible are Black Tartarian, Black Eagle, Knight's Early Black, in the

hearts, and Robert's Red Heart, Mezel, Tradescant's Black Heart and Windsor in the firm-fleshed varieties.

Family sorts.—For the family varieties the hearts are among the best on account of their tender, luscious flesh, though in point of excellence, some of the bigarreaus are close competitors. I would recommend the following varieties for family use :

Hearts.—Black Tartarian, Governor Wood, Coe's Transparent, Belle d' Orleans, Downer's Late Red, Black Eagle, Knight's Early Black.



89.—*Windsor.*

Bigarreaus.—Napoleon, Rockport, Robert's Red Heart, Yellow Spanish and Windsor.

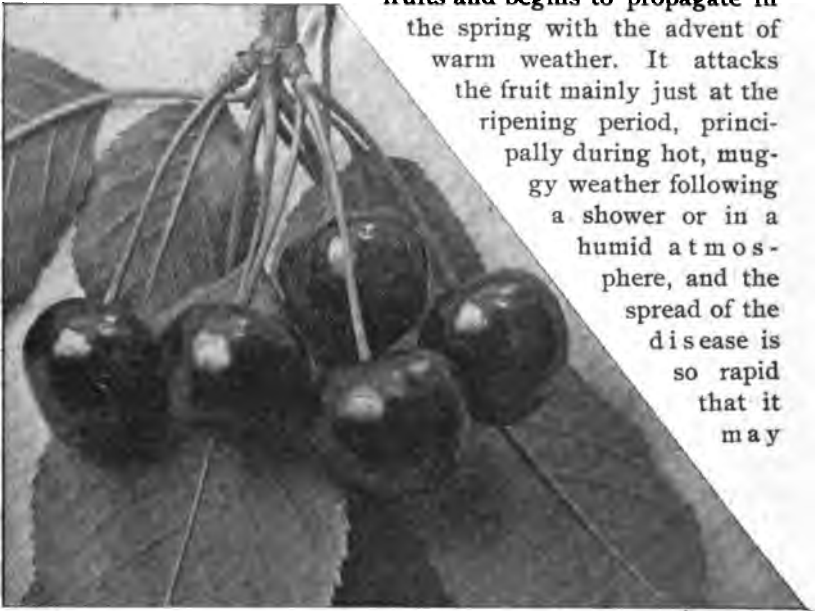
Dukes.—May Duke, Belle de Choisy.

There are other varieties which are probably equally as good, but these can be recommend from long acquaintance.

Diseases.—The cherry is attacked by the same diseases that are common with plums, the principal one of importance affecting it being the fruit rot. The symptoms are familiar to all. The fruit turns brown and ash-colored tufts appear on it, which are the spore-bearing threads, and later the fruit falls, or becomes mummified and persists for a long time without decaying.

The twigs, leaves and flowers may also be attacked by the disease, causing the flowers to decay and die and the leaves to become discolored. The fungus passes the winter in the mummified

fruits and begins to propagate in the spring with the advent of warm weather. It attacks the fruit mainly just at the ripening period, principally during hot, muggy weather following a shower or in a humid atmosphere, and the spread of the disease is so rapid that it may



90.—*May Duke.*

ruin an entire crop in twenty-four hours.

It is said by some that hand picking of the diseased fruit and parts will prevent the spread of the disease, as it destroys the means by which the fungus passes the winter. This method is not practicable, because not more than a part of the fruit will be gathered, and because of the labor attached to it.

It has been shown that spraying with Bordeaux mixture will control the difficulty and also prolong the ripening season.

The directions given by Craig* are that the trees should be carefully sprayed with Bordeaux mixture after the blossoms fall and that two or three applications should be made, the last being with ammoniacal copper carbonate a few days before picking. The application should probably be made every two weeks. I should substitute the ammoniacal carbonate of copper for the Bordeaux after May 1, as traces of Bordeaux will remain on the trees for a month or more.

I am not convinced, however, that spraying is necessary to prevent the brown rot in New York state. The losses from this disease which have come under my observation are invariably the result of letting the fruit hang on the trees till ripe and then the rot is very active ; but cherries should be picked a few days before ripe, before they soften, and then the rot does not seriously affect them. An illustration of this point, which is a most important one, was brought to my notice the present season. The last week of June, in eastern New York, was very hot and close with showers every day or two. The cherries were then ripening and the conditions were favorable for the rot to spread. In one orchard from which several tons of cherries were shipped that week, there was not more than 150 lbs. destroyed by the rot, while in another orchard a few miles distant at least 10 tons of the same varieties were ruined on the trees. In the first orchard the fruit was picked before it had ripened, and all that was fit was taken off *as soon as the trees dried off after a shower*; in the other orchard it was left till nearly ripe and one-half to two-thirds of the crop was lost before the fruit could be picked. So rapid is the work of this fungus at this period, that the owner of the orchard told me that he lost 3 tons of one variety in one night. It might be added that the orchard first mentioned was a much stronger one, as it was in cultivation, while the last had been in sod for years, and the general debility and neglect of the trees made them good subjects for the attacks of rot or any other disease.

The most serious insect pests are the black aphid and curculio. The aphid often attacks young trees and sometimes the bearing ones. They appear early in the season and multiply very fast.

*Bull. 23 Central Exp. Farm, Ontario.

This aphid is found in great numbers on the young shoots and the under side of leaves and on the stems of the fruit, excreting a sticky substance which covers the pests; and the leaves curl up. It may appear as late as September but seldom in sufficient numbers to do injury. The aphid is a sucking insect and has to be treated with kerosene emulsion or whale oil soap, of which one or two thorough sprayings is generally sufficient to clear the trees. The spray must be applied *as soon as the aphid appears*, or the attacked leaves curl with the insect inside and it is impossible to reach them, and the full grown insect is very hard to kill. In such cases it is advised to pick the affected leaves and destroy them if possible and then spray so as to kill the remaining ones on the twigs and fruit.

The full treatment of the curculio is to be made the subject of a separate bulletin.

EPITOME.

Cherry growing is one of the neglected industries of western New York. There are practically no bearing orchards of sweet cherries, and very few of sour cherries.

The product is sold both in the open market and to canneries. In general, the factories afford the better market, although well grown and nicely packed fruits, particularly of the sweet kinds, find a ready sale in the general market.

Cherries like a loamy soil which is rich in mineral food. They should generally be given clean and frequent cultivation until the fruit is ripe, and after that the land may be put to rest with some cover crop. Stimulating or nitrogenous manures should be used cautiously.

Sour cherries should be planted 18 to 20 feet apart each way, and sweet cherries about ten feet farther.

Cherries are pruned after the manner of pruning plums and pears. Sweet cherries should be pruned to three to five main arms, and not to a central leader. (Page 396.)

The curculio is the worst enemy to sweet cherries, and it is sometimes serious upon the sour kinds. Jarring the trees is the most reliable procedure.

The rot, due to a fungus, is particularly bad upon the early and soft-fleshed sweet cherries. Spray for it twice before the fruit is

half grown, with Bordeaux mixture. Plant varieties least susceptible to the disease (see page 407, 410). Be expeditious in handling the crop.

Cherries for the general market should be carefully hand-picked, with the stems on, and they should be neatly packed in small packages. Cherries for the general market, particularly the sweet kinds, should be handled with as much care as strawberries are. The smallest packages are the most profitable for the best cherries. (Page 399.)

The most deserving sour cherries for western New York are Montmorency, English Morello and Louis Phillippe. The last is best in quality, but apparently is least productive.

Of sweet cherries, the following are recommended for market : Windsor, Napoleon, Black Tartarian, Black Eagle, Mezel, Robert's Red Heart, Downer's Late Red. For home use, Black Tartarian, Governor Wood, Coe's Transparent, Belle d'Orleans, Downer's Late Red, Black Eagle, Knight's Early Black ; Napoleon, Rockport, Robert's Red Heart, Yellow Spanish, Windsor ; May Duke, Belle de Choisy.

L. H. BAILEY,
G. H. POWELL.

630.679

N7

C8.6

Bulletin 99.



August 10, 1895.

Cornell University Agricultural Experiment Station.

HORTICULTURAL DIVISION.

BLACKBERRIES.



By L. H. Bailey.

PUBLISHED BY THE UNIVERSITY.

ITHACA, N. Y.

1895.

ORGANIZATION.

BOARD OF CONTROL: THE TRUSTEES OF THE UNIVERSITY.

STATION COUNCIL.

President, JACOB GOULD SCHURMAN.

Hon. A. D. WHITE,	-	-	-	-	Trustee of the University.
Professor I. P. ROBERTS,	-	-	-	-	President State Agricultural Society.
Professor I. P. ROBERTS,	-	-	-	-	Agriculture.
Professor G. C. CALDWELL,	-	-	-	-	Chemistry.
Professor JAMES LAW,	-	-	-	-	Veterinary Science.
Professor A. N. PRENTISS,	-	-	-	-	Botany.
Professor J. H. COMSTOCK,	-	-	-	-	Entomology.
Professor L. H. BAILEY,	-	-	-	-	Horticulture.
Professor H. H. WING,	-	-	-	-	Dairy Husbandry.
Professor G. F. ATKINSON,	-	-	-	-	Cryptogamic Botany.

OFFICERS OF THE STATION.

I. P. ROBERTS,	-	-	-	-	-	Director.
E. L. WILLIAMS,	-	-	-	-	-	Treasurer.
H. W. SMITH,	-	-	-	-	-	Clerk.

ASSISTANTS.

M. V. SLINGERLAND,	-	-	-	-	-	Entomology.
GEO. C. WATSON,	-	-	-	-	-	Agriculture.
G. W. CAVANAUGH,	-	-	-	-	-	Chemistry.
E. G. LODGMAN,	-	-	-	-	-	Horticulture.
MICHAEL BARKER,	-	-	-	-	-	Horticulture.

Office of the Director, 20 Morrill Hall.

Those desiring this Bulletin sent to friends will please send us the names of the parties.

BULLETINS OF 1895.

84. The Recent Apple Failures in western New York.
85. Whey Butter.
86. Spraying of Orchards.
87. The Dwarf Lima Beans.
88. Early Lamb Raising.
89. Feeding Pigs.
90. The China Asters.
91. Recent Chrysanthemums.
92. Feeding Fat to Cows.
93. The Cigar-Case-Bearer.
94. Damping Off.
95. Winter Muskmelons.
96. Forcing-House Miscellanies.
97. Entomogenous Fungi.

On account of the technical nature of Bulletin 97, only a limited edition was printed for the use of Experiment Stations and exchanges.

98. Cherries.
99. Blackberries.

CORNELL UNIVERSITY, ITHACA, N. Y., Aug. 20, 1895.

THE HONORABLE COMMISSIONER OF AGRICULTURE, ALBANY.

Sir.—This account of the blackberry is submitted for publication and distribution under Chapter 230, of the Laws of 1895.

L. H. BAILEY.



91.—*Merseureau Blackberry*, four-fifths natural size. Description on page 455.

BLACKBERRIES.

The blackberry is a neglected fruit in western New York. There are few persons who make any special attempt to grow it at its best upon a commercial scale. Yet, there is no bush fruit which is capable of yielding greater profit. It is the last of the small fruits, and when it is well grown it affords a luscious addition to the dessert of midsummer. Some of my readers will at once take issue with me respecting the lusciousness of the blackberry, and we may as well argue the subject to a finish whilst we are in the mood. In justification of my position, I shall say that those persons who do not like the garden blackberry have probably never eaten a ripe one. Those red and juiceless objects which one finds frying in the sun and patronized by flies in front of grocery stores are not the fruits about which I am writing. They might have been green berries or red berries, but they were never ripe blackberries. There is no fruit grown in this state which so soon deteriorates after picking, and none which is necessarily picked in such unfit condition. The blackberry is not ripe simply because it is black ; it must be soft, and it must drop into the hand when the cluster is shaken. In this condition it is full of the sweetness and aroma of midsummer. It is our most delicious bush fruit. Of course, such berries as these never find their way to the market, and hence it comes that my reader who has never grown the fruit is still wincing in memory of the unbearable acid of the blackberry. Then there are those who declare that the tame berry is intolerably sourer than the wild one. It is true that it is more juicy when well grown, and this juice is very sour until the berry is soft to the core. But the flavor of the wild berry is usually quite as much a compound of pleasant memories of youthful associations and stimulating adventures as it is of sweetness and flavor ; and then, when one picks wild berries he always selects the ripest and the best, and these become the standard with which he compares the untimely fruits which he buys of the groceryman. I also held tenaciously to the opinion that the tame

berry is inferior to the wild one until, a few years ago, I visited the wild patch in which grew those incomparable berries of my boyhood. But I found the berries scant and seedy, many of them inexcusably sour, and the briers were intolerable. I came back to my Agawams with relish, and they are to this day my ideal of summer fruits.

There seem to be three important difficulties in the raising of blackberries in this state: one is the slow price which sometimes prevails when there is a heavy competing crop of early peaches; another is the winter-killing of the plants; and the third is the effect of droughts. Respecting the first difficulty, I can only say that it is rarely serious if the fruit is well grown and attractively handled. Prices are generally good for worthy blackberries. With ourselves, they sell the best of any small fruit. The winter-killing is avoided by planting the hardiest varieties and by taking care not to keep the plants growing too late, and by heading-in the canes early so that the laterals become well matured. The effects of dry weather are often serious because the blackberry is largely water, and it ripens in the hottest part of the year. But the difficulty can be almost wholly avoided in New York by care in selecting land which does not quickly suffer from drought, and especially by early, frequent and timely cultivation.

Land.—The best blackberry land is a deep, mellow, clay loam; that is, a soil of which the body is clay,—and which, originally, might have been very hard,—but which contains considerable humus and crumbles rather than bakes in the furrow. Loose, gravelly lands are too deficient in water for the blackberry. It is very important to plow all hard lands deep and to fit them with much care before setting the plants, for, if the plants are to escape the effects of droughts, the roots must go deep and there must be a liberal reservoir for water upon the foundation or hard-pan. Flat lands with high subsoil should always be tile-drained before blackberries are set upon them, else the bushes will generally suffer in winter, and the fruit is also more liable to injury from mid-summer droughts. It is generally best to set blackberries in the spring, and strong yearling plants are commonly used. One may use the suckers which spring up about blackberry bushes for setting, or he may grow them from root cuttings. The suckers

are almost wholly used by commercial berry-growers. These may sometimes be transplanted with success even after they have started to grow in spring.

Planting.—The plants are usually set in a furrow six or seven inches deep, and if the land is thin, stable manure may be scattered in the furrow. For all the ordinary large-growing varieties, eight feet between the rows is enough. This allows of easy cultivation. For myself I like them far enough apart to admit two horses in cultivating, as shown in the picture in our plantation, on the title-page. Two horses and a spring-tooth cultivator are the most efficient means which I have yet found of keeping a blackberry plantation in condition. In large plantations, it is well to leave out a row occasionally, to allow of a roadway. In the row, the plants are set from two to three feet apart. They will soon spread and fill the row. There are some growers who prefer to set the plants six or seven feet apart in the row in order to cultivate both ways, but this is profitable only where it is possible to give extra attention to tillage and pruning for the purpose of producing fine dessert fruit.

The year the plants are set, potatoes or other crops may be grown between the rows, and the yield should be sufficient to pay for the use of the land. Some growers plant strawberries, not only between the rows but sometimes in the row between the plants; and it is possible, by good cultivation, to obtain two good crops of strawberries before the blackberries smother them.

Three or four canes may be allowed to grow the first year if the plants put out vigorously, and these will bear some fruit the following year. As soon as the canes have reached a height of two or three feet, they should be headed back.

Training.—The subsequent training of the blackberry is simple, and it is essentially like that demanded by the raspberry. The operator must know, of course, that the shoots or canes which spring from the root one year will bear fruit the next year and that their usefulness is then ended. Every year, therefore, the canes which have borne fruit are cut out, and others are allowed to grow from the root to take their places. It is generally preferable to remove these canes as soon as the fruit is off, that is, in late August or early September; but the operation is usually de-

layed until a less busy season. They should always be removed before growth begins the following spring. These old canes are simply cut off close to the surface of the ground with long-handled shears, a spud or a cutting hook. Whilst the canes are bearing, others are growing from the root to take their place. A strong root may send up from ten to twenty shoots, but only a few of them should be allowed to remain. How many shall be left must depend entirely upon the vigor of the plant, closeness of planting, strength of soil, and like circumstances. Usually five or six canes from each root are sufficient, and if very excellent fruit is desired,



92.—*Early Harvest Blackberry patch in August. (Roland Morrill, Benton Harbor, Mich.)*

the number may be reduced. The strongest canes should be left and the others pulled out when they are still only four or five inches high. It will be necessary to go over the patch four or five times early in the season to remove these superfluous shoots. It is true that many growers entirely neglect this thinning of the young shoots, but it is a question if better results would not always follow their removal.

These growing canes should be headed-in,—two to four inches of the tips cut off,—when they are from two and a half to three feet high. It will be necessary to go over the plantation three or four times for this purpose, as the different canes reach the desired height at different times. Laterals will now push out vigorously, but these are allowed to grow their full length. Early the following spring, these laterals are shortened. There is no



93.—*Blackberries on trellis.*

rule respecting the proper length to leave these laterals. Sometimes they are injured by the winter and must be cut in short. And there is great difference in varieties in the way in which they bear their fruit; some kinds, like Wilson Early, bear the

fruit close to the cane, whilst others, like Snyder and Early Harvest, should be cut longer. Some varieties are variable in their habit of bearing fruit, and on such kinds some growers prefer to delay the pruning of laterals until the blossoms appear. From twelve to twenty inches is the length at which the laterals are generally left. It must be remembered that these laterals are to bear most of the fruit; hence it is important that they make a good growth, become well matured, and that the grower familiarize himself with the habits of different varieties. It is generally important that the heading-in of the main cane be done early, so that the laterals may make an early and hard growth, and that they may start rather low down on the cane and thereby prevent the cane from tipping over with its load of fruit.

Blackberry bushes which are managed as I have outlined above will stand alone, without stakes or trellises. Such bushes are shown on the title-page (Early Cluster) and a smaller-growing variety (Early Harvest) in Fig. 92. The bushes are sometimes kept from lopping by stretching a single wire along either side of the row, securing it to stakes which stand two or three feet high.

In some places, particularly along the Hudson, blackberries are trained on wires, after the manner of grapes. A blackberry trellis is shown in Fig. 93. The two-wire trellis is generally preferred. The young canes are headed-in just above the upper wire, and they are gathered in bunches in the hand and tied to the upper wire, where they will least interfere with the ripening fruit. These canes may remain on the wires all winter, or they may be laid down for protection. Early the following spring, they are tied securely to both wires. This makes, therefore, one summer tying for the young canes, and one spring tying for the bearing canes. Blackberries may also be tied to single stakes, although the practice is scarcely advisable because the fruit is apt to become too much massed in the foliage. Dewberries, however, which make a less rampant growth, are trained to stakes to great advantage, and when they are well grown, they are capable of becoming a valuable addition to the berry plantation, because they sell as blackberries and ripen a week or ten days earlier. Some growers in this state find the Lucretia dewberry to be as

profitable as the blackberry, and one or two correspondents even prefer it.*

Winter protection.—Protection in winter is rarely, if ever, necessary in western New York if the bushes are upon the proper land, if they have been judiciously cultivated and pruned, and if the hardier varieties are grown. Blackberries are extensively laid down in colder climates, however, and it may be well to relate the method here for the benefit of those who occupy bleak locations. Late in fall, the bushes are tipped over and covered. Three men are generally employed to perform this labor. One man goes ahead with a long-handled round-pointed shovel and digs the earth away six inches deep from under the roots. The second man has a six-tined or four-tined fork which he thrusts against the plant a foot or so above the ground, and by pushing upon the fork and stamping against the roots with the foot, the plant is laid over in the direction from which the earth was removed. The third man now covers the plant with earth or marsh hay. Earth is generally used, and if the variety is a tender one, the whole bush is covered two or three inches deep. Hardy varieties may be simply held down by throwing a few shovelfulls of earth on the tops of the canes, thus allowing the snow to fill in amongst the canes. If the grower lives in a locality where he does not fear late spring frosts, the bushes should be raised early in the spring; but if frosts are feared they may be left under cover until corn-planting time. If the buds become large and are bleached white under cover, they will suffer when exposed to the atmosphere; and one must watch the bushes in spring and raise them before the buds become soft and white. This method of laying down blackberry plants costs less than \$10 per acre, and the slight breaking of the roots is no disadvantage. Some growers dig the earth away on both sides of the row, and still others bend over the canes without any digging. Whatever method is employed, the operator must be careful not to crack or split the canes. The method can be varied with different varieties, for some bear stiffer canes than others.

* A full account of the dewberries will be found in our Bulletin 34, which, however, is now out of print.

Cultivation—No fruit profits more from careful tillage than the blackberry. This is largely because the fruit requires so much water, if it reaches its full capabilities, and the crop matures in the driest part of the season. The moisture of the soil can be well conserved only when tillage is begun very early in the spring. We generally plow our patches in the spring, and thereafter keep the land in fine shape by running over it every week with a cultivator. We generally prefer a spring-tooth cultivator, as shown on the title-page. It is especially important to cultivate as soon after a rain as the soil is in condition, before it bakes. This tillage is continued until within a day or two of picking time. After the crop is harvested, one good cultivation is given to loosen up the ground which has been tramped down by the pickers and to fit it for winter. With us, this last cultivation occurs about the middle or last of August. In the drier summers west of New York, blackberry growers often mulch with freshly cut clover or manure close about the plants, leaving the center of the rows open for cultivation; but this is rarely, if ever, necessary in this state.

These frequent light cultivations are really cheaper than one or two, because the weeds never get a chance to grow and little hoeing is necessary. If a patch becomes foul with thistles and other weeds, the best procedure is to mow it off, plow it up thoroughly and crop it with corn for a season. Suckers will come up in the corn along the old rows, and the following year the plantation will be completely renewed.

Stable manure is the most popular fertilizer for blackberries. In general, it may be said that if the tillage is good, nitrogen will rarely be needed on good lands. Potash and phosphoric acid as advised for orchards (Bulletin 72) may no doubt be applied to advantage.

Yields and profits.—The year following the planting, there should be a sufficient yield to pay for the cost of the plantation to that time. The third year, the crop should be large, and from that time on, the yields should be nearly uniform, when the seasons are good. I do not know the limit to the profitable age of a blackberry plantation. It is certain that it should continue to bear heavily for twenty years if it has good care, and I am told by careful growers that a patch will last even longer than this.

As the plants are generally grown, however, they cannot be expected to hold out this long, for the land becomes hard and foul, and the plants full of dead and diseased wood.

Blackberries are capable of yielding 200 bushels per acre, year by year, unless very unfavorable seasons intervene. This station once made an inquiry *amongst fifty growers in various parts of the country as to the average yield of blackberries. The lowest return was 40 bushels, the highest over 300 bushels, and the average of the whole fifty was 98 bushels per acre. The prices in this state range from seven to fifteen cents a quart. J. M. Mersereau, of Cayuga, one of our best blackberry growers, recently said to me: "Let me choose the soil, and I will guarantee to clear \$200 per acre on blackberries." In our own experience at Ithaca, blackberries have sold the most readily of any of the bush fruits, at prices ranging from eight to fifteen cents per quart. Granville Cowing, Muncie, Indiana, a most successful grower of this fruit, makes me the following statements respecting the profits of it: "The blackberry is probably the most profitable of the small fruits. Owing to its firmness it can be kept much longer in good condition than the strawberry or raspberry, and often brings better prices. The best varieties are enormously productive, their cultivation comparatively easy, and a well kept plantation of them should last a life time." Whilst all these figures and statements are tempting, it must nevertheless be said that the blackberry, like all other fruits, yields the golden harvest only to those who work for it, and who think whilst they work.

Accidents and diseases.—The only serious accident which is known to injure the blackberry crop in this state is frost; and in most cases the injury is unavoidable, even though the grower has warning of its approach. In the six crops which we have grown in our patches here, only this year have we suffered from frost, and even this year, when the cold wave was unusually late and severe, only the lowest places suffered seriously. Drawings of blackberry flowers were made upon the spot, two or three days after the frost, and they are here reproduced, natural size. A normal, uninjured flower is shown in Fig. 94. Inside the five

*"Raspberries and blackberries," by Fred W. Card, Bulletin 57. (Now out of print).

white petals or leaves, are seen the numerous sprawling stamens or so-called male organs, each one bearing an enlargement or anther on the end, inside which the pollen is borne. In the center of the flower is the head or cluster of pistils or so-called female organs, each of which ripens into one of the little grains which go to make up the blackberry. The frost killed these organs, so that the centre of the flower bore only a small black column of dead pistils (Fig. 95). Now and then, one or more of these pistils in the head escaped and developed into a fruit-grain, so that the berry became a "nubbin." Fig. 96 shows the dead and aborted fruits at picking time. At the top of the picture are some fruits in which one or two grains or drupes are full grown, whilst all the rest of the berry did not develop.



94.—Blackberry flower, full size.

There are four diseases of the blackberry which may be mentioned here,—the red rust or yellows, root-gall, anthracnose, and cane-knot. Except the last, these diseases will be more fully described in Bulletin 100, and they need not be discussed here. It may be said, however, that all these troubles can be kept at bay by keeping the patch tidy,—cutting out all suspicious canes and bushes, and by clean and careful culture. The yellows (*Cæoma nitens*) or red or orange rust of the leaves, is incurable, and the affected bush should be pulled out and burned as soon as discovered. With this treatment, there is no difficulty in keeping a patch clean of the disorder. The same remarks apply to the root-gall. Anthracnose, or pitting of the canes, is less serious in blackberries than in black raspberries. It can no doubt be kept in check by careful spraying with Bordeaux mixture, as described in Bulletin 100; but I believe that the most efficient treatment is to cut out and burn the old canes just as soon as the fruit is off, and to examine the bushes frequently for the disease and to cut out the diseased shoots. If a patch became very seriously in-



95.—Blackberry flower injured by frost.

volved, I should want to mow the bushes off close to the ground in fall or early spring, clean out the crowns and spray them, and start a wholly new top. This

would sacrifice one year's crops, but the results would not be doubtful. The cane-knot (Fig. 97) is a disease of which the cause is unknown. In fact, I do not know that it has been described. The picture is an excellent

lent picture of it. The knot reminds one strongly of the plum-knot, but there are numerous small whitish eruptions of the disease surrounding the parent knot.



96.—Cut by frost.

It may be of fungous origin, although we have not been able to discover constant deep-seated fungi on the knots which have been sent us. It probably attacks the growing shoots, although it is not apparent until the following year, when the grower, noticing that the leaves are yellow and the fruit not filling, examines the canes and finds these knots upon them. We have never had the disease in our own patches, and therefore cannot give advice for its treatment, although I should advise the same sanitary treatment as I have for anthracnose. It is apparently not common, but it must be widespread, for I have had specimens from as far west as Wisconsin. Mr. D. F. Harris, Adams, New York, gives me this experience with the knot: "I came into possession of my patch three years ago. Variety said to be Snyder. The first year, a few

canes were diseased; second year, about half of them were diseased; third year, nearly all diseased. I think that the disease begins to show in early spring on the old canes. I have never found it on the present year's canes. It progresses rapidly, as the fruit grows, and when the fruit is about two-thirds grown the leaves begin to wither, the cane dries up, and the berries ripen. On very badly diseased canes, the berries wither and dry up."



97.—*Cane knot.*
Full size.

Types and varieties.—What a silent evolution the blackberry has undergone! It is not yet fifty years since the first named blackberry, the *Dorchester*, was introduced to general notice. In 1857, the *New Rochelle*, or *Lawton*, was exhibited before the Massachusetts Horticultural Society, and thereupon blackberry culture began to attract wide attention in the country. The *Lawton* held undisputed sway until it was superseded by the *Kittatinny* some ten or fifteen years later. The *Kittatinny*, in turn, gave way to the *Snyder* in about ten or fifteen years, and this latter variety is now the leading commercial blackberry. In the meantime, however, a host of varieties had appeared, very many of them wildings or chance bushes found in fence-rows and copses, but so quietly have they come in that no one has been sufficiently attracted by them to enquire minutely into their genesis or to attempt to classify them into botanical groups. Consequently, the botanical features of the cultivated blackberries are little understood, which indicates that the crop has received little scientific attention. The garden blackberries, as I understand them, fall into five categories:

I. *Long-cluster blackberries* (*Rubus villosus*). Best represented by *Taylor* (Fig. 104), although *Early Cluster* (Fig. 103), and *Ancient Briton* are evidently to be referred to the group. It represents the commonest large-fruited form of the wild blackberry, which grows in moist shady copses or in woods. This wild berry is seen natural size in Fig. 98. This form is distinguished by a long, loose, open and leafless cluster of long-stemmed, elongated

fruits, very tall growth, leaflets mostly long-stalked, rather thin, evenly and rather finely serrate, and taper-pointed. Typical fruits of this class are cylindrical-thimble-shaped, the drupelets rather small and uniform.

II. *Short-cluster blackberries* (*Rubus villosus*, var. *sativus*, Bailey, Amer. Gard. 1890, 719).—This is the commonest form of cultivated blackberry, and includes such varieties as New Rochelle, Kitteninny (Fig. 101), Snyder (Fig. 100), Agawam (Fig. 102), Erie, Minnewaski, and Mersereau (Fig. 91). A typical cluster of this group is shown in Fig. 91. It is comparatively few-fruited, leafy, the stems oblique rather than spreading, the top-most fruits more or less aggregated. The fruits are rounder than in group I., the drupelets larger and mostly softer and less uniform in arrangement.



98.—*The tall, wild blackberry. Life size.*

The leaflets are broader, more abruptly pointed, and generally very coarsely and unevenly serrate or even jagged. In its wild form, this blackberry is common in open and dryish places, where it forms a bush generally only two or three feet high, bearing a short cluster of small roundish mostly loose-grained fruits. The varieties of this type have a strong tendency

to produce a few later fruits on the tips of the new growth. These late fruits often ripen as late as the first week in September.

III. *Leafy-cluster blackberries* (*Rubus villosus*, var. *frondosus*,

Torr). — These are dwarf, strict bushes, generally growing on dryish soils, bearing the flowers in short leafy clusters (Fig. 99), the leaflets small and firm, more or less wrinkled, light colored, persisting long in the fall, smooth or nearly so when full grown, narrow, coarsely toothed. Fruit early, roundish, medium to small, the grains large and rather loose. This is a very leafy plant, and is no doubt a distinct species from the common blackberry. In cultivation, it is known in the Early Harvest



99.—Cluster of Early Harvest.

and Brunton's Early.

IV. *Loose-cluster blackberries* (*Rubus villosus* × *R. Canadensis*). — A mongrel class, comprising Wilson Early, Wilson Jun-

ior, Sterling Thornless, Rathbun, and probably Thompson's Early Mammoth. The class is characterized by a low and often diffuse growth, broad jagged and notched leaves, mostly loose-grained, roundish or roundish-oblong fruits, which are sometimes very large, and particularly by the few flowers scattered on long stems towards the end of the canes. Sometimes, as in the Rathbun and others, the canes have a distinct tendency to root at the tip, after the manner of the dewberry. These blackberries are hybrids of the common blackberry and the dewberry. All of the cultivated sorts, so far as I know, are natural hybrids, or, like the Wilson Junior and Sterling, offsprings of a natural hybrid (Wilson Early). Natural hybrids are common along roadsides in central New York.

V. *Sand blackberry* (*Rubus cuneifolius*).—The Tree Blackberry of Childs, and the Topsy, are forms of this viciously



100.—Snyder. Full size.

thorny species, which grows wild in sandy lands from southern New York southwards. It is a low plant (2 to 3 feet high), the cultivated forms suggesting the Early Harvest type. In wild specimens the under surfaces of the thickish, wedge-obovate leaflets are white with a thick hairy covering, but much of this disappears under cultivation. The fruit is borne in loose leafy clusters, and

is globular, loose-grained, very black, often sweet and of excellent quality. I do not know of any cultivated forms which are valuable.

The varieties of blackberries which are much esteemed in New York are few. I append brief descriptions of a few of them.

The various recent kinds are not yet sufficiently tested to warrant a description of them in a paper of character.

Snyder (Fig.



101.—*Killatanny*. Natural size.

100).—By far the most popular blackberry in this state. Early, hardy, very productive. Berries of medium size, nearly globular, of fair quality when well ripened. The one serious defect of the Snyder is the tendency of the fruit to turn red when placed upon the market, particularly if it is picked be-

fore fully ripe. This difficulty may be obviated somewhat by keeping the berries covered after they are picked, to exclude the light. This, in fact, should be done with all blackberries. Found wild over forty years ago in northern Indiana.

Minnewaski.—Much like the Snyder, and popular along the



102.—*Agawam*. Natural size.

Hudson. Comes in just after Snyder and averages larger, but, under all conditions, it does not seem to be so uniformly productive, and it is not so hardy. As commonly consumed it is very

sour, but its quality is excellent when it is allowed to ripen on the bush.

Kittatinny (Fig. 101).—One of the oldest and best known blackberries, of most excellent quality and the fruit long and large, but now little grown in New York because of its tenderness and susceptibility to red rust. In somewhat protected localities and on well drained soils, it generally passes the winter safely if cultivated judiciously ; but it is not generally reliable in this state.

Ancient Briton.—One of the most popular varieties in Wisconsin, where it first became known, and one which we have grown for a number of years and which we find to be very valuable. It is one of the hardiest varieties, very productive, about the season of Snyder or a trifle later, the berries large, long, of first-rate quality. The bush is a sturdy grower, and if headed back early in the season it stands very stocky and erect. There is much conflict of opinion in New York respecting this variety, and I suspect that much of the stock is spurious. It was "brought to this country from Great Britain about 40 years ago by a Mr. Guy, for the late Robert Hassell, of Alderly [Wisconsin], who gave it the name."*

Agawam (Fig. 102).—A large berry of most excellent quality, generally ripening with Ancient Briton. Fruit oblong, in rather heavy clusters. Productive and hardy with us, and we consider it one of the best, particularly in quality.

Erie.—Tender in western New York; therefore little known here.

Early Cluster (Fig. 103).—This has been the most uniformly productive of any variety which we have grown, and we have fruited about 200 plants of it for five years. It is as hardy as Snyder, and is fully a week earlier. A moderate, erect grower, with medium-sized fruits in long and open clusters. There seems to be much misconception respecting this variety. Some growers report it to be tender and worthless. We procured our stock of Ellwanger & Barry, and I have sent the fruit to John S. Collins, the introducer, who pronounces it to be "Early Cluster, without doubt." Original plant found about 1872 amongst Missouri Mammoth, on farm of Chas. W. Starn, New Jersey. Introduced in 1883.

* A. Clark Tuttle, Amer. Gardening, xiv. 305.

Taylor (Fig. 104).—Very hardy, as productive as Snyder, the long, thimble-like fruit borne in immense clusters and of the very best quality. It is about two weeks later than Snyder, ripening with the old Lawton, and generally closes the blackberry season in this state. One of the very best.

Mersereau (Fig. 91, page 416).—A variety strongly resembling the Snyder, and derived from it, but not yet generally disseminated. Its advantages over Snyder are its larger size, less tendency to turn red after being picked, better quality, and a stronger habit of perfecting some of its fruits as late as the first of September. Its ordinary season is that of the Snyder. This variety originated with J. M. Mersereau, Cayuga, New York, for whom I am glad to name it.*



103.—*Early Cluster. Half size.*

Some three or four years ago, Mr. Mersereau noticed an extra good bush amongst his Snyders, and began to propagate from it. He is now gradually changing his whole plantation

*It was described, briefly, as "Mersereau's Seedling" in Bull. 81, new series, New York State Experiment Station (Geneva), December, 1894.



104.—Taylor. *Three-fourths life size.*

over to this new variety, which differs from Snyder, in addition to the points mentioned above, by the much lighter cast of its foliage. It is one of the most promising varieties which I know.

Early Harvest and *Wilson Early* are little grown in this state. It is commonly supposed that both of them are very tender, but *Early Harvest* stands our winters fairly well. *Wilson*, however, needs protection ; and both varieties are easily laid down, because of their dwarf habit. Their particular merit is earliness, although *Wilson* is also very large. These varieties are exclusively grown by Roland Morrill, Benton Harbor, Michigan, who is president of the Michigan Horticultural Society, and one of the most successful fruit growers in the state (see Fig. 92). *Wilson Early* is an old variety, having been planted extensively in New Jersey thirty years ago. The *Wilson Junior*, which is practically indistinguishable from it, was grown from seeds of it, supposed to have been crossed with *Dorchester*, which were selected in 1875, by William Parry.*

BRIEF.

Blackberries deserve greater attention from western New York fruit-growers.

The tame berries are, as a rule, superior to the wild ones if they are allowed to hang on the bushes until fully ripe.

No bush fruit deteriorates so rapidly after being picked.

Winter-killing of the plants, which is a serious menace to blackberry growing, is avoided by selecting hardy varieties, planting upon thoroughly well drained land, and stopping cultivation as soon as the fruit is off. Or the bushes may be laid down, as described on page 423.

Drought often cuts the crop short. This difficulty is to be avoided by selecting lands which are not droughty, by thin planting, and by beginning tillage early in the spring and continuing it at frequent intervals until the fruit is nearly ripe. The method of cultivation which this bulletin advises is found on pages 424 and 419.

Blackberries are generally planted in the spring. Eight or nine feet should be allowed between the rows, and two to three

*William Parry, "Fifty Years among Blackberries," 4.

feet between the plants in the row. Potatoes or other crops may be grown between the rows the first year.

Training and pruning are described on pages 419 to 423.

Blackberries yield all the way from nothing to 300 bushels per acre. The variations in the yields measure the alertness and intelligence of the grower. One hundred bushels to the acre may be considered to be a good average yield. A fair crop should be obtained the year after the plants are set, and a good one the second year. A blackberry plantation may continue to be profitable for twenty years or more.

The way in which spring frost injures blackberries is shown by pictures 94, 95, and 96; and an account of it may be found on page 425.

There are various diseases which thrive in half-kept blackberry plantations, but which may be headed off if the owner is alert and diligent. See pages 426 and 427.

No one can tell the intending blackberry grower what varieties he ought to plant. The grower must find that out for himself. But if he lives in western New York, he will be likely to succeed with Snyder, Taylor, Early Cluster, Ancient Briton, Agawam and Minnewaski; and he should try all others. Very early varieties are Early Harvest, Wilson Early, Wilson Junior, and Early Cluster; Snyder is medium early; Taylor is very late.

One who is curious to know about the botanical features of our cultivated blackberries, may read pages 428 to 431.

L. H. BAILEY.

